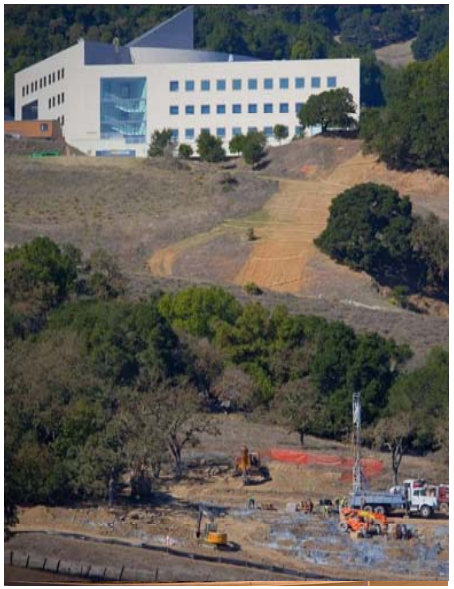


Geothermal Heat Exchange Systems:

Case Studies & Lessons Learned

Date: April 11, 2013

PRESENTED TO: GOLDEN GATE ASHRAE CHAPTER

Presented By:
Marco Alves, PE – Senior Associate
John Paul Peterson, PE – Senior Associate

inspire interpret integrate

Sustainable Projects

U.S. Green Building Council Member	109 LEED Projects	22 Platinum 62 Gold 21 Silver
International Living Building Institute™	4 Living Building Projects	
Net-ZERO Countdown...Net-Zero and Beyond	9 Net Zero Energy Projects	
Passive House Alliance	2 Passive House Projects	

Agenda:

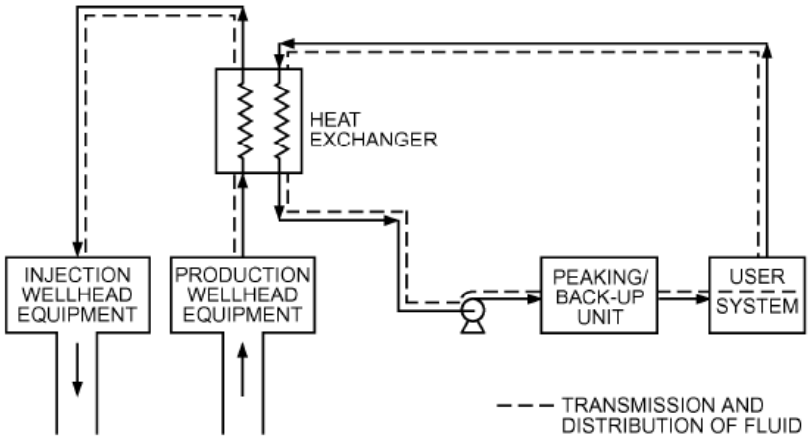
- What is Geothermal
- Geothermal Design
- Guidelines and Codes
- Geothermal Construction
- Geothermal = Energy and Water efficiency
- Cost and Incentives
- Design Case Study
- Case Studies
- Q & A

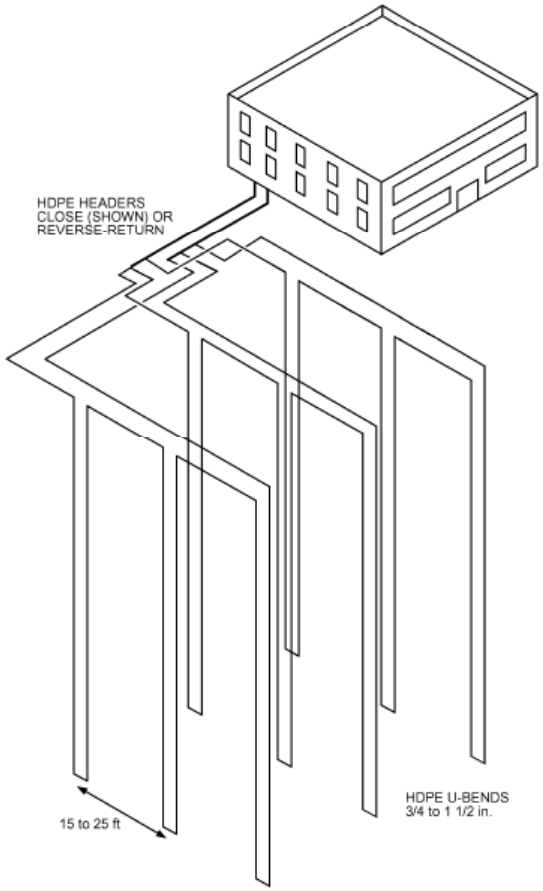
What is Geothermal?

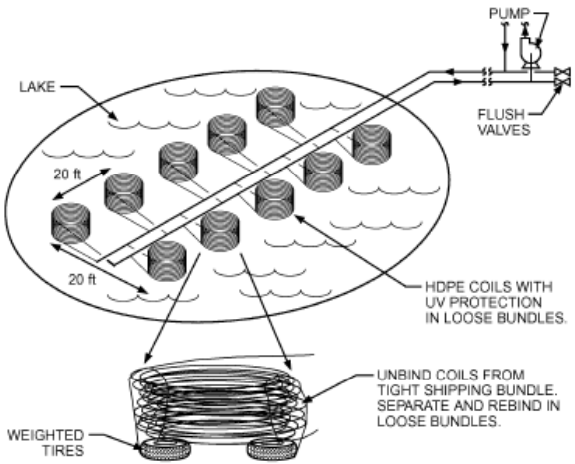
It is **NOT**

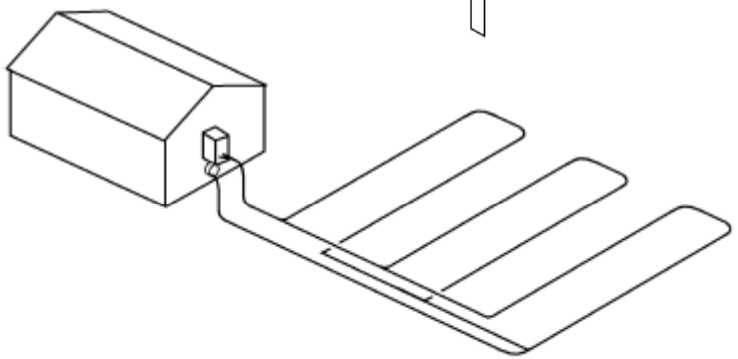
Geothermal Design

Geothermal Heat Exchange





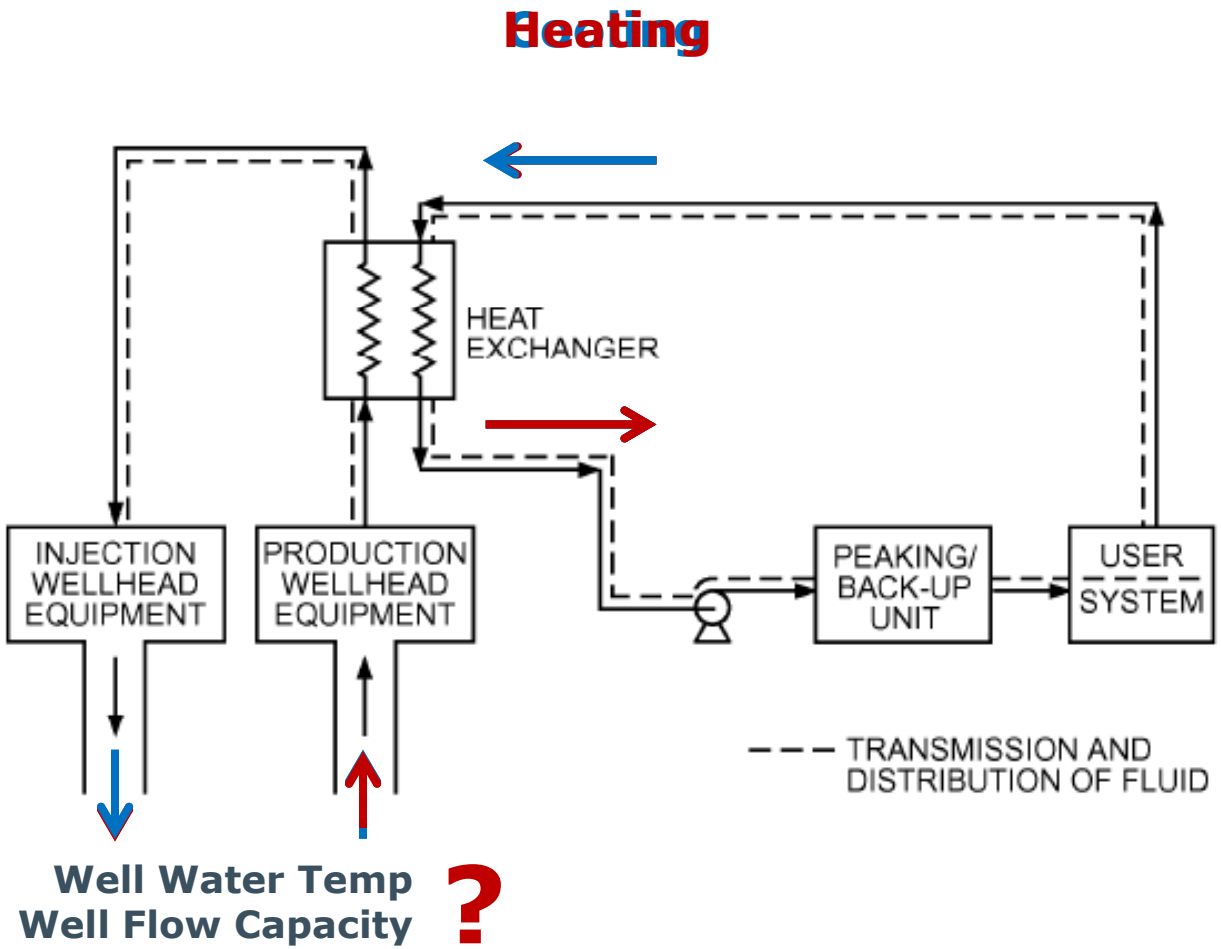




Source: ASHRAE

Geothermal Design

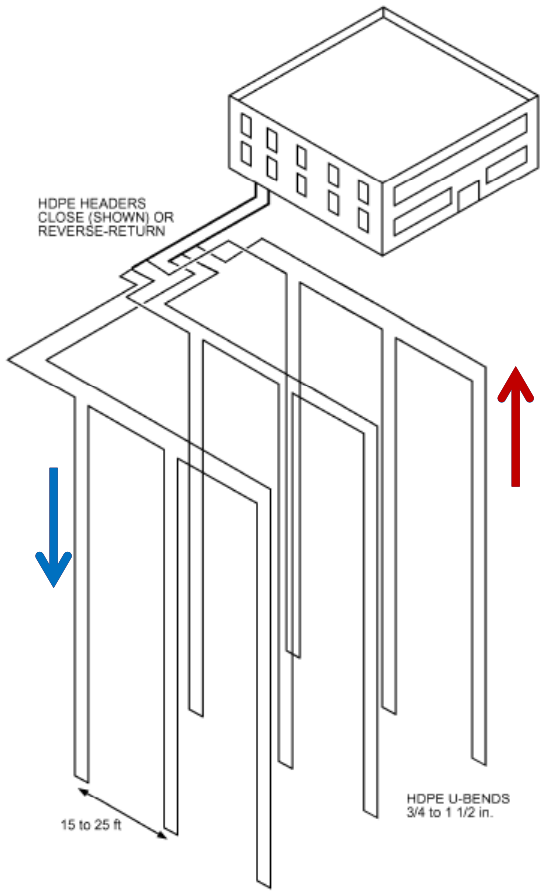
Open Loop/Well Design



Source: ASHRAE

Geothermal Design

Closed Loop/Bore Design

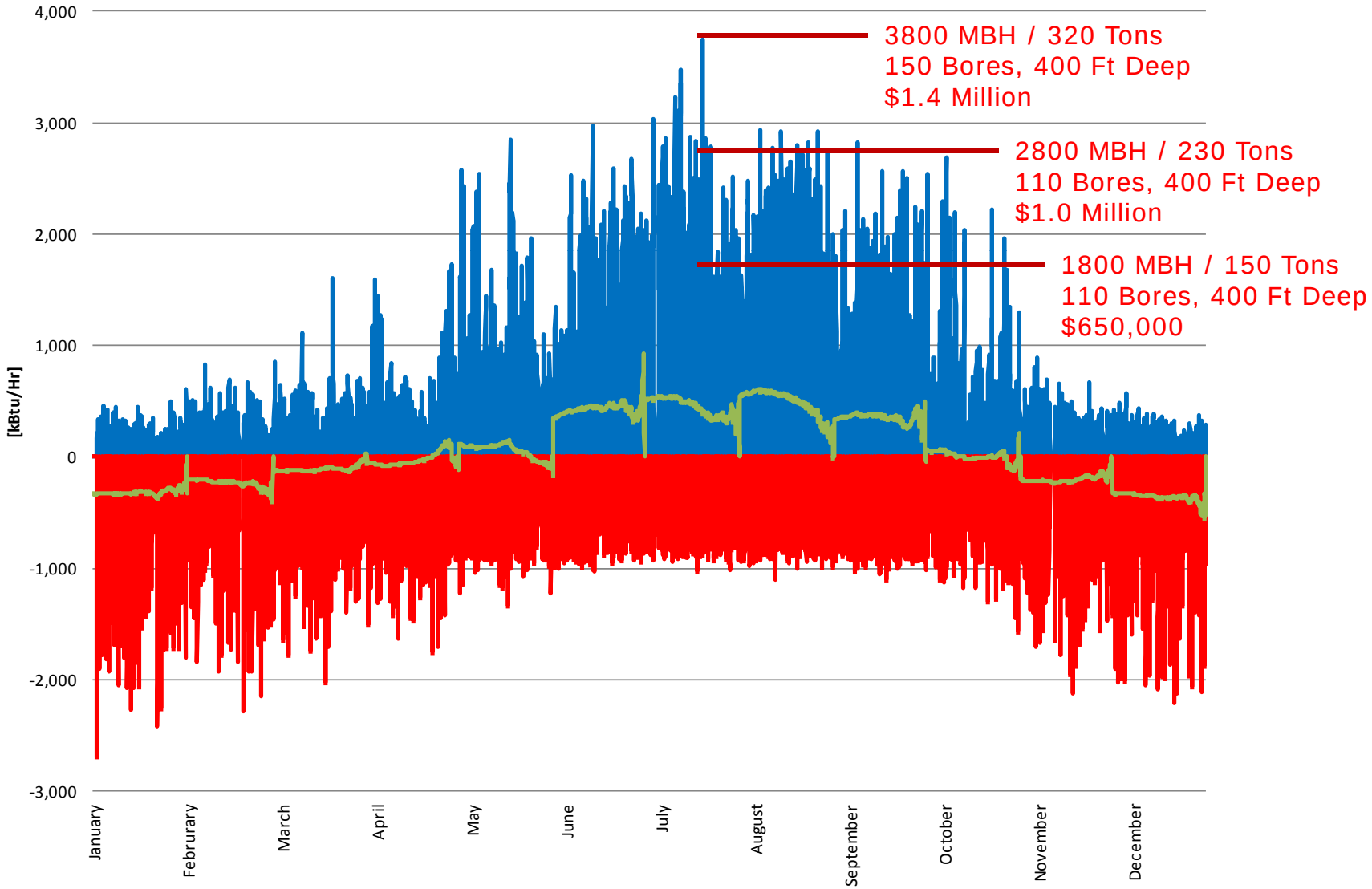


Geological Formation
Ground Temp
Bore Capacity **?**

Source: ASHRAE

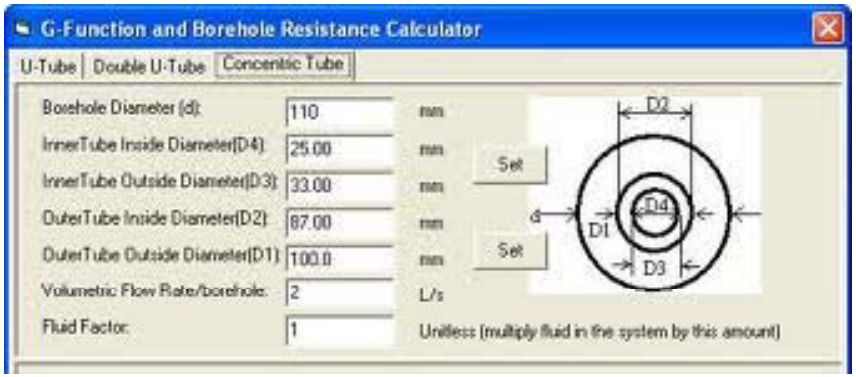
Geothermal Design

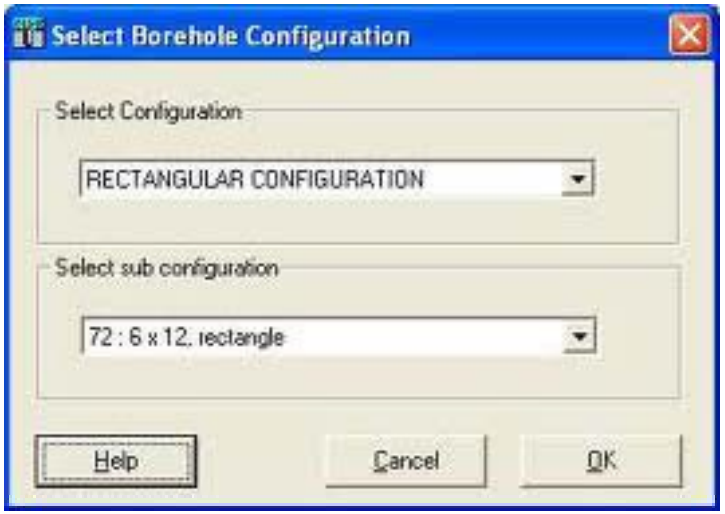
Building Load Profile

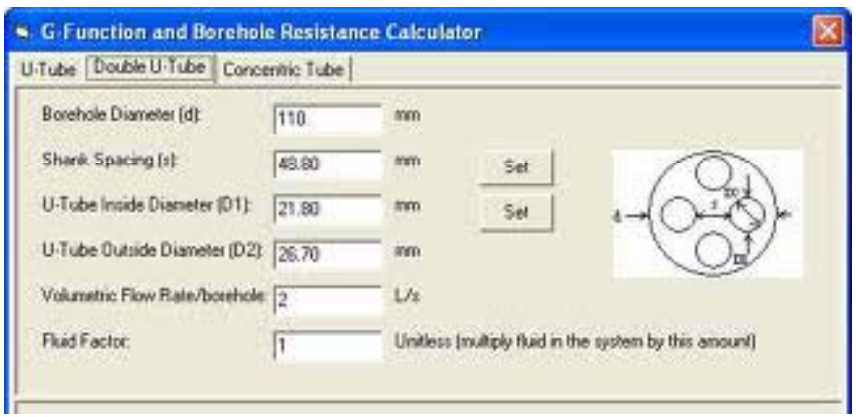


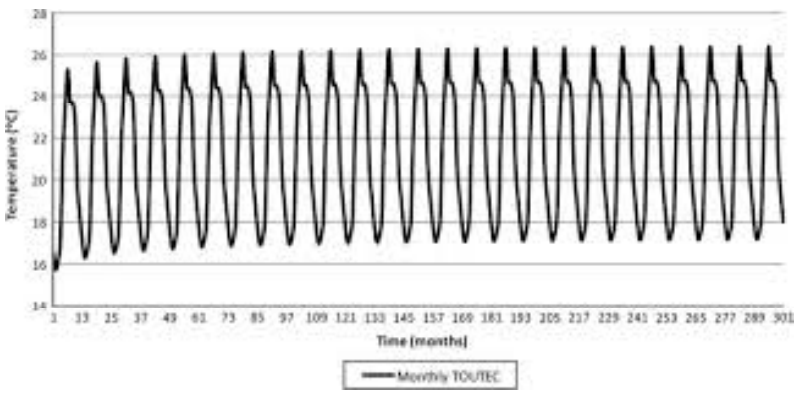
Geothermal Design

Software Modeling



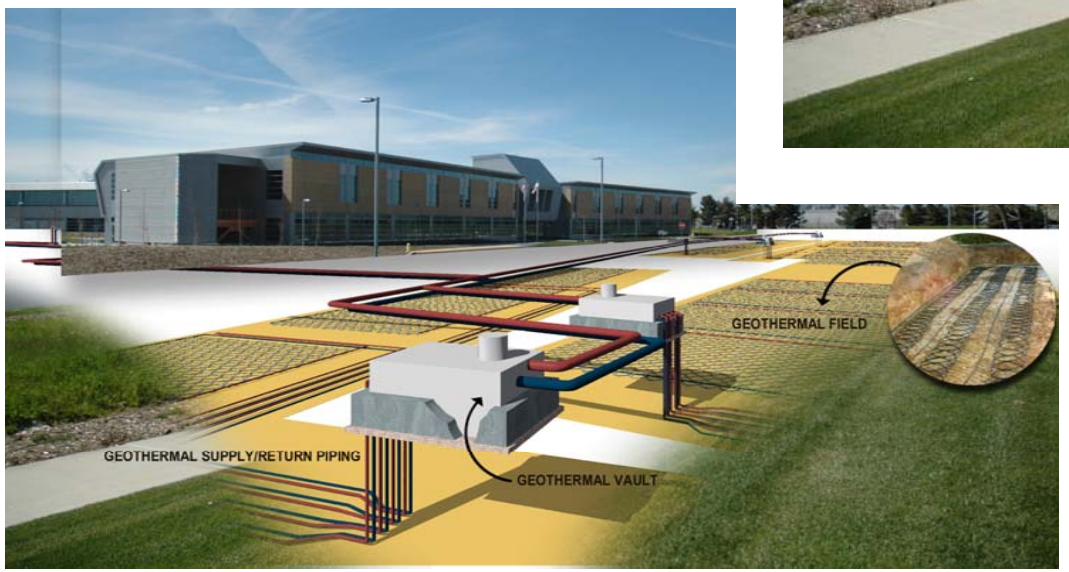






Geothermal Design

Field Design



Guidelines and Codes

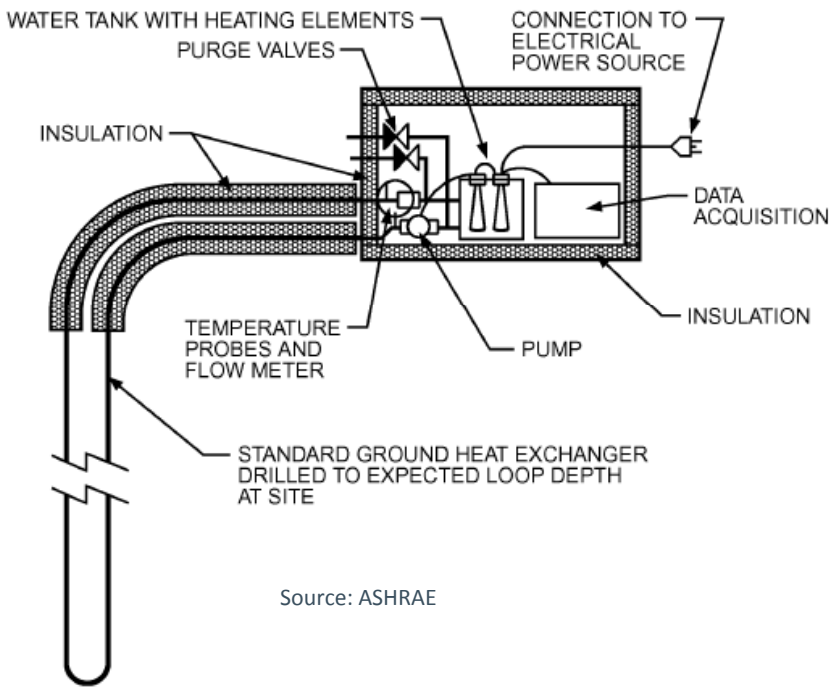
CALIFORNIA
ENERGY COMMISSION

DEPARTMENT OF
WATER RESOURCES

Guidelines and Codes

ASHRAE & IGSHPA

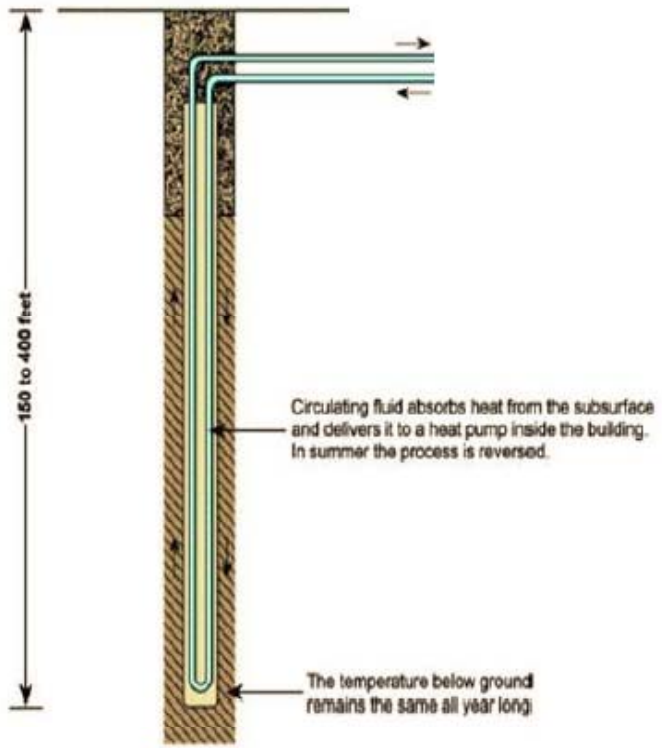
Test Bore



Source: ASHRAE

INTERNATIONAL GROUND SOURCE HEAT PUMP ASSOCIATION

Bore Design/Construction



Guidelines and Codes

CEC – AB 2339

CALIFORNIA ENERGY COMMISSION

AB 2339 (Williams & V. Manuel Pérez)
Renewable Thermal Energy Deployment Act

SUMMARY

AB 2339 requires the California Energy Commission (CEC) to identify and address existing barriers to the deployment of geothermal heat pumps and geothermal ground loop technologies.

NEED FOR THE BILL

There should be a statewide effort to identify and address why such readily available, efficient and cost effective technologies are not widely used in California.

AB 2339 directs the CEC to evaluate, and recommend policies and implementation strategies to address the barriers impeding the use of geothermal technologies in California.

ENERGY.GOV: Geothermal = Renewable Energy

Guidelines and Codes

DWR – GHEW Standards Update

DEPARTMENT OF WATER RESOURCES

GHEW Standards – Draft Created in 1999

GHEW Standards – Draft Being Updated

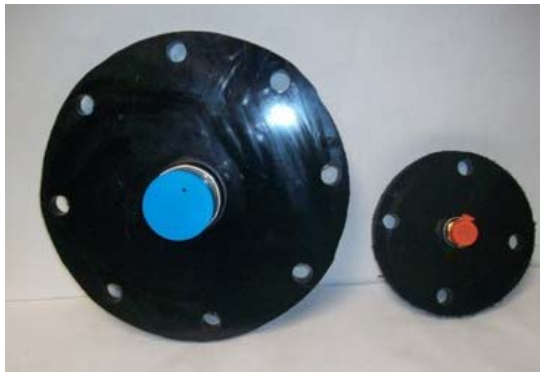
Closed Loop Systems – DWR GHEW Standards Apply

Open Loop Systems – DWR Water Well Standards Apply

Local Water Agency is AHJ

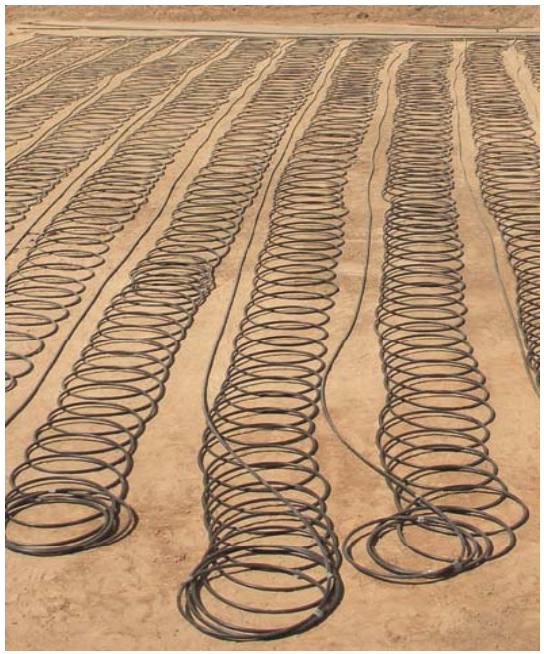
Geothermal Construction

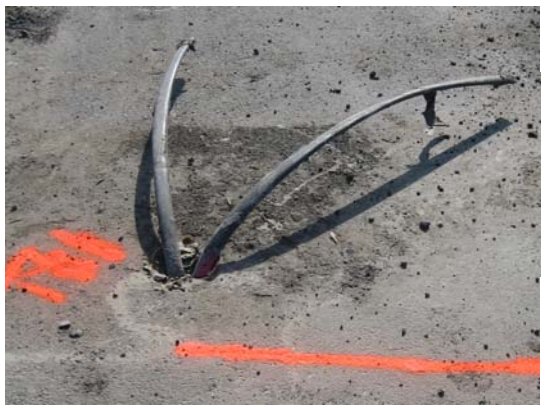
Pipe & Fittings



Geothermal Construction

Pipe, Trenches, Bores, & Drill rigs





Geothermal Construction

Vaults & Valves

Geothermal Construction

Why HDPE?

Smooth Walls and Same Hydraulic Capacity Over Lifetime

Reduced Pressure Loss

50 to 100 Year Lifetime

50 Year Pipe Warranty

Potable Water Use

Recyclable

AWWA
ASTM
NSF
CSA

Non Toxic

Chemical & Corrosion Resistance

1600 psi Hydrostatic Design Basis at 73°F per ASTM D-2837

Geothermal: Energy Water Nexus

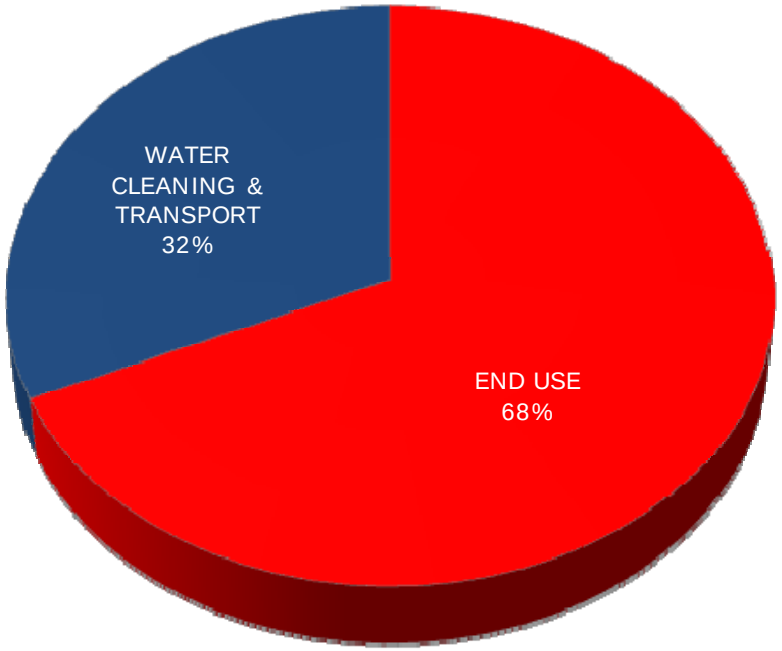
CEC 2005 Report

Table 1-1: Water-Related Energy Use in California in 2001

	Electricity (GWh)	Natural Gas (Million Therms)	Diesel (Million Gallons)
Water Supply and Treatment			
Urban	7,554	19	?
Agricultural	3,188		
End Uses			
Agricultural	7,372	18	88
Residential	27,887	4,220	?
Commercial			
Industrial			
Wastewater Treatment	2,012	27	?
Total Water Related Energy Use	**48,012**	**4,284**	**88**
Total California Energy Use	**250,494**	**13,571**	?
Percent	**19%**	**32%**	?

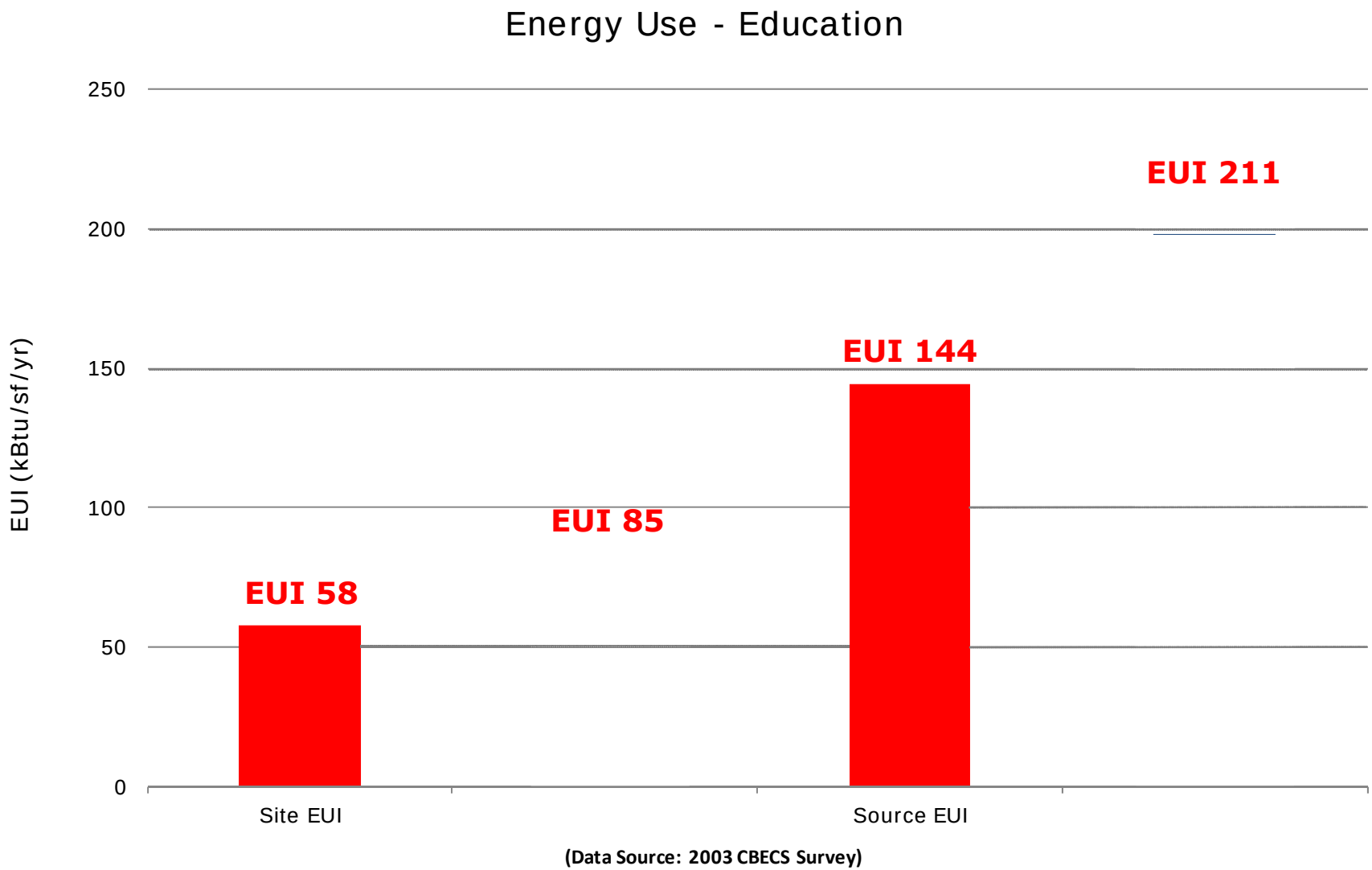
Source: California Energy Commission

CA WATER RELATED ENERGY USE



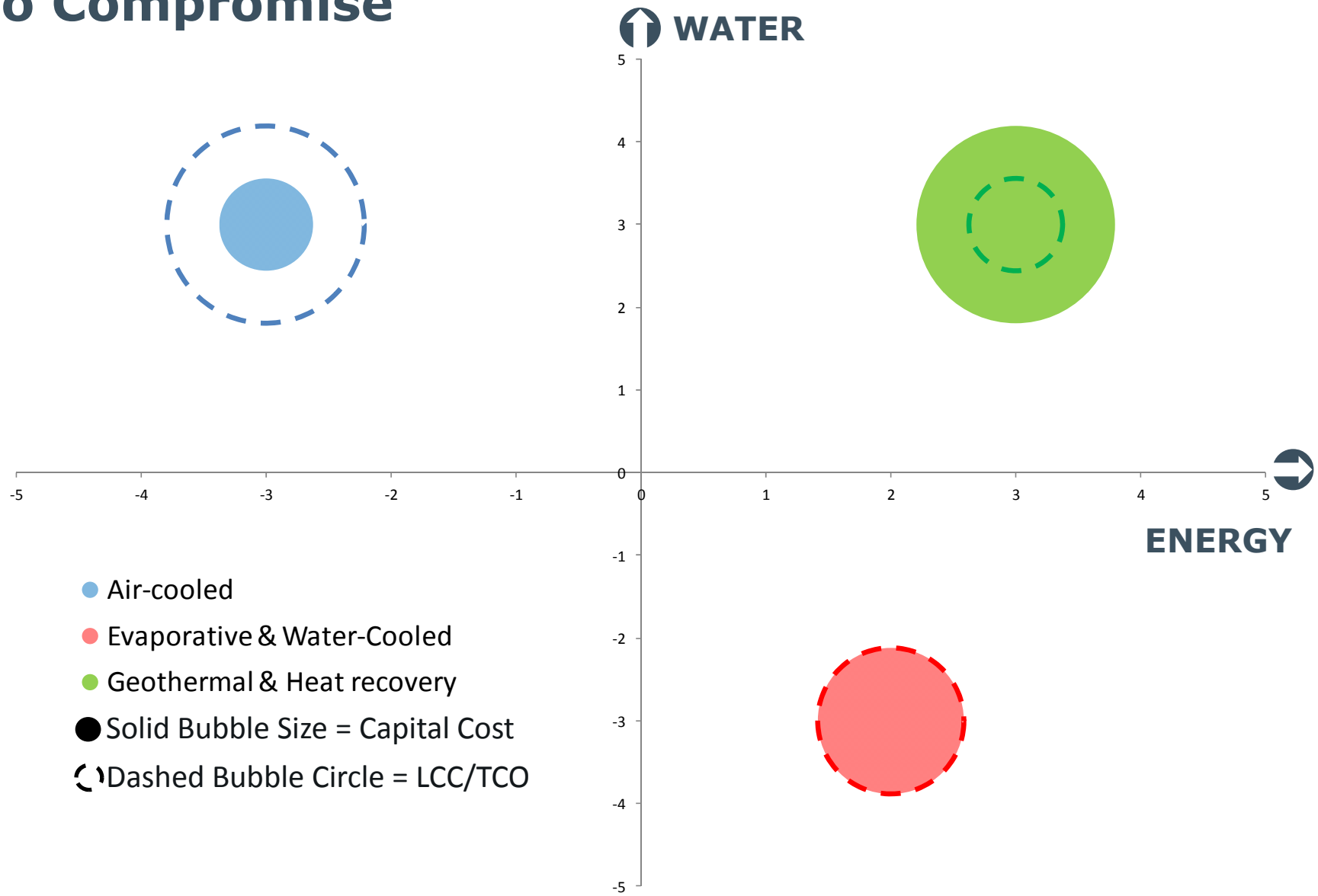
Geothermal: Energy Water Nexus

CEC 2005 Report



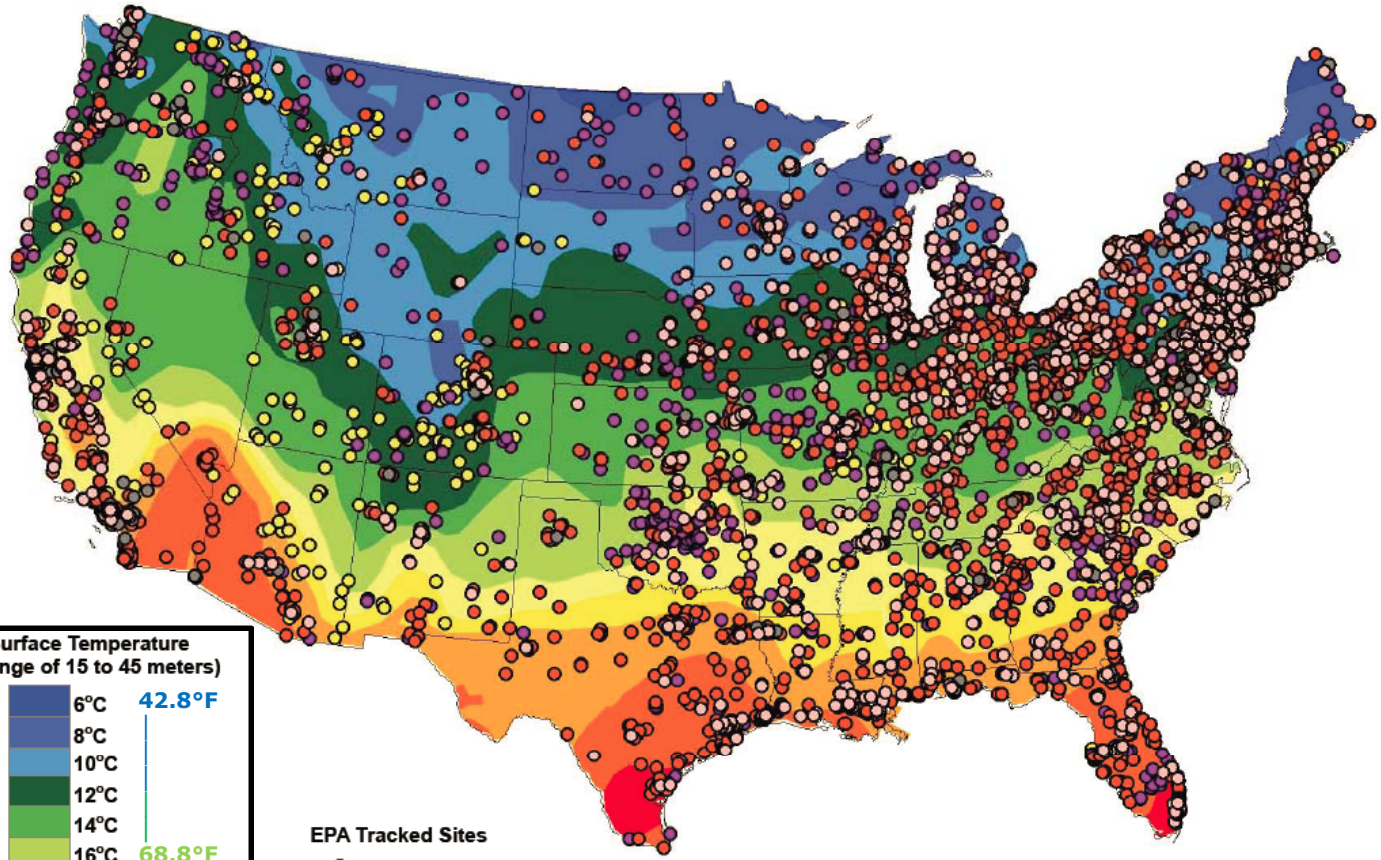
Geothermal: Energy and Water

No Compromise



Geothermal: Energy Efficiency

EPA Tracked Sites with Geothermal Heat Pump Siting Potential



Near Surface Temperature
(depth range of 15 to 45 meters)

6°C	42.8°F
8°C	
10°C	
12°C	
14°C	
16°C	68.8°F
18°C	
20°C	
22°C	
24°C	
26°C	78.8°F

EPA Tracked Sites

- Abandoned Mine Land
- Brownfield
- RCRA
- Federal Superfund
- Non-Federal Superfund

Screening Criteria

Near surface temperature, well depth, property size, and distance to electric transmission lines and roads are not screening criteria

All sites are generally considered favorable for geothermal heat pumps, though sites with near surface temperatures of 10°C to 24°C are preferred

EPA

This map was developed by SRA International for the US Environmental Protection Agency (EPA) OSWER Center for Program Analysis. Results are based on site screening criteria adapted from National Renewable Energy Laboratory (NREL) criteria and GIS data provided by Southern Methodist University (SMU) Geothermal Laboratory, NREL and EPA. This map and its associated data are intended to provide a general understanding of the renewable energy potential of EPA tracked sites; ***additional site-specific technical and economic analysis is required to determine the actual energy generation potential of EPA tracked sites****. For further information, please see the accompanying Data Guidelines document at www.epa.gov/renewableenergyland or contact cleanenergy@epa.gov.*

U.S. EPA OSWER
CENTER FOR PROGRAM ANALYSIS

Cost and Incentives

Cost of Geothermal:

- Vertical Bore ~$4,000/Ton
- Horizontal Slinky ~$3,500 **(+ Site Work Costs)**

Federal Incentives

- MACRS + Depreciation: 50% year 1 + 12.5% years 2-5
- Investment Tax Credit (ITC): 10% year 1

Finance Solutions

- GeoTPA (LVESTUS, Others..)

No CA State Incentives

- Not yet Considered Renewable
- Coming soon?

U.S. DEPARTMENT OF
ENERGY
Energy Efficiency &
Renewable Energy

Design Case Study

30,000 SF Lab

Design Case Study

30,000 SF Lab, 3 Stories, Detention Pond

Design Case Study

Energy Analysis

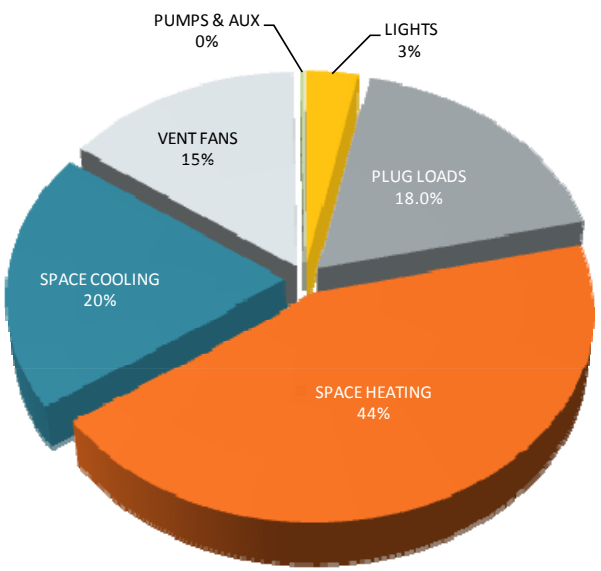
Options	Simulation Summary	Total Energy Use			% Energy Savings vs Baseline
		Electricity (kWh)	Natural Gas (Therms)	EUI (kBtu/sf/yr)	
T24	VAV Air Handlers with HW Reheat (T24 Base Option)	951,621	25,545	207	BASE
1a	Water Cooled Heat Recovery Chiller, Domestic Water Heat Exchanger	976,720	0	119	42.6%
1b	Option 1a with Four Pipe VAV in Dry Labs	1,004,393	0	122	40.9%
1c	Option 1a with Four Pipe VAV in Wet Labs	953,121	0	116	43.9%
2	Water Cooled Heat Recovery Chiller, Closed-Loop Geothermal Array	941,564	0	115	44.6%
3a	Condensing Boiler and Air Cooled Chillers	644,761	20,253	151	27.2%
3b	Option 3a with Four Pipe VAV in Wet Labs	647,017	18,383	144	30.3%
4	Condensing Boilers, DX Lab Air Handler, Packaged Office Air Handler	936,002	17,734	164	20.8%

$0 K

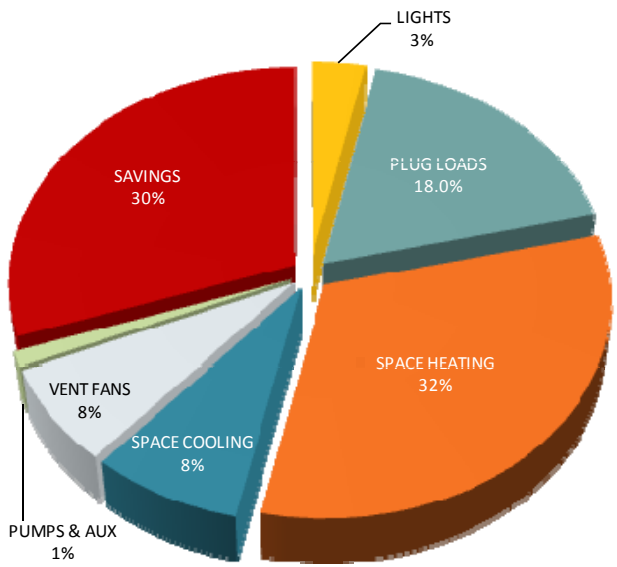
$850,000

Water flow data not available

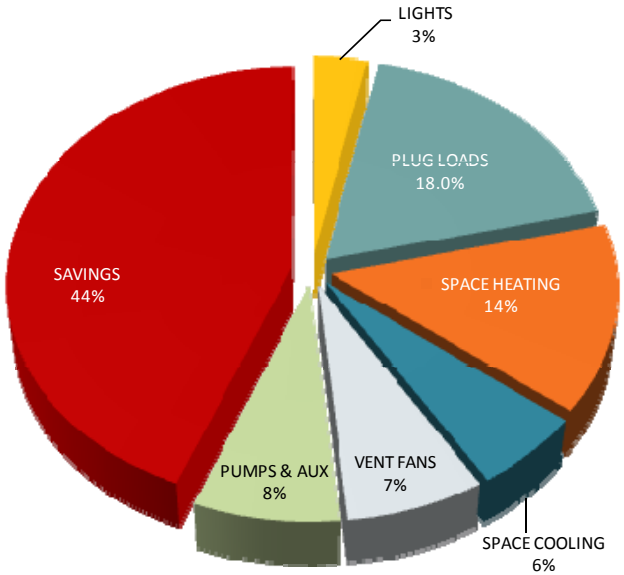
Title 24 HVAC



Proposed Option 3b

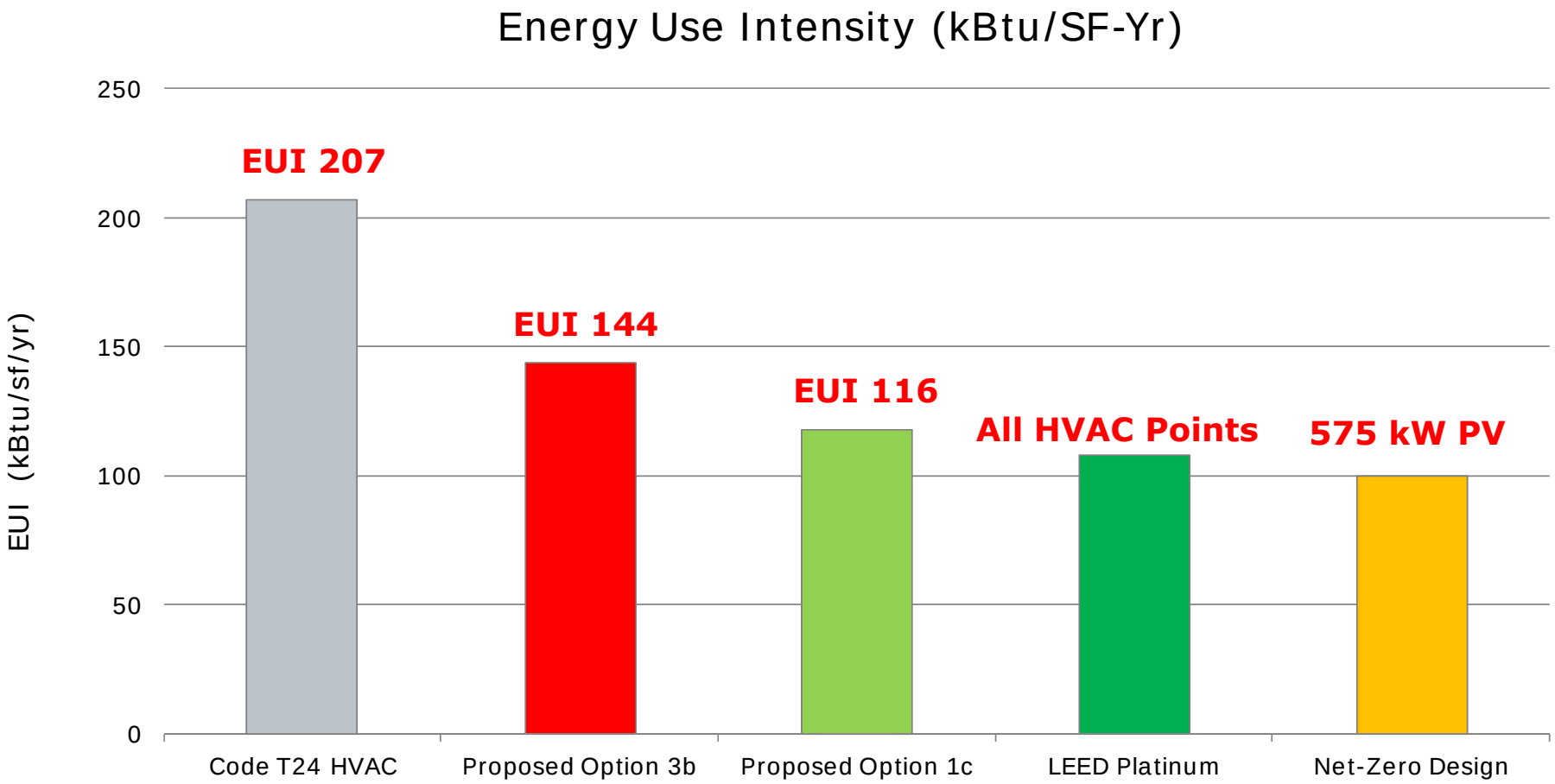


Proposed Option 1c



Design Case Study

Net-Zero?



Design Case Study

LCC

LIFECYCLE COST ANALYSIS

	BASED ON 30 YEAR ANALYSIS - 2013 to 2042									
BASE Options	OPTIONS	Capital Costs ($)2013	Avg. Maint. Costs ($)	Avg. Repla. Costs ($)	Utility Costs ($)2013	Savings By Design Rebate ($)2013	Payback T24 Base (Years)	15 Year Cost of Ownership ($)2027	30 Year Cost of Ownership ($)2042	Energy Use Index (kBtu/sf-yr)
	T24 HVAC - Air Cooled DX AHU's + VAV Reheat	$2,529,000	$17,444	$39,808	$136,834	$0	-	$5,833,123	$13,105,219	207
1a	Water Cooled Heat Recovery Chiller + Domestic Water HX	$2,970,000	$20,616	$43,779	$122,091	$25,545	8	$5,520,789	$12,320,698	119
1b	1a + Four Pipe VAV in Dry Labs	$2,948,500	$20,616	$43,779	$125,549	$0	11	$5,599,453	$12,554,489	122
1c	1a + Four Pipe VAV in Wet Labs	$3,000,000	$20,616	$43,779	$119,140	$25,545	8	$5,487,111	$12,154,637	116
2	Water Cooled Heat Recovery Chiller + Geothermal HX	$3,850,900	$20,616	$43,779	$117,696	$27,556	23	$6,304,840	$12,907,588	115
3a	Air Cooled Chillers + Condensing Boilers	$2,970,000	$17,444	$45,101	$94,772	$66,664	8	$5,386,663	$10,876,047	151
3b	3a + Four Pipe VAV in Wet Labs	$3,000,000	$17,444	$45,101	$93,745	$68,083	8	$5,393,083	$10,836,396	144
4	Air Cooled DX AHU's for Lab and Office + Condensing Boilers	$2,580,000	$17,444	$39,808	$129,414	$0	7	$5,724,010	$12,663,243	177

Notes / Assumptions:

1. Average Price for Natural Gas is $0.70/Therm.
2. Average Price for Electricity is $0.125/kWh.

Design Case Study

LCC w/ Geo Fed Incentives (GeoTPA)

LIFECYCLE COST ANALYSIS

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2	Water Cooled Heat Recovery Chiller + Geothermal HX	$3,850,900	$20,616	$43,779	$117,696	$27,556	2	$4,871,935	$11,474,683	115
3a	Air Cooled Chillers + Condensing Boilers	$2,970,000	$17,444	$45,101	$94,772	$66,664	8	$5,386,663	$10,876,047	151
3b	3a + Four Pipe VAV in Wet Labs	$3,000,000	$17,444	$45,101	$93,745	$68,083	8	$5,393,083	$10,836,396	144
4	Air Cooled DX AHU's for Lab and Office + Condensing Boilers	$2,580,000	$17,444	$39,808	$129,414	$0	7	$5,724,010	$12,663,243	177

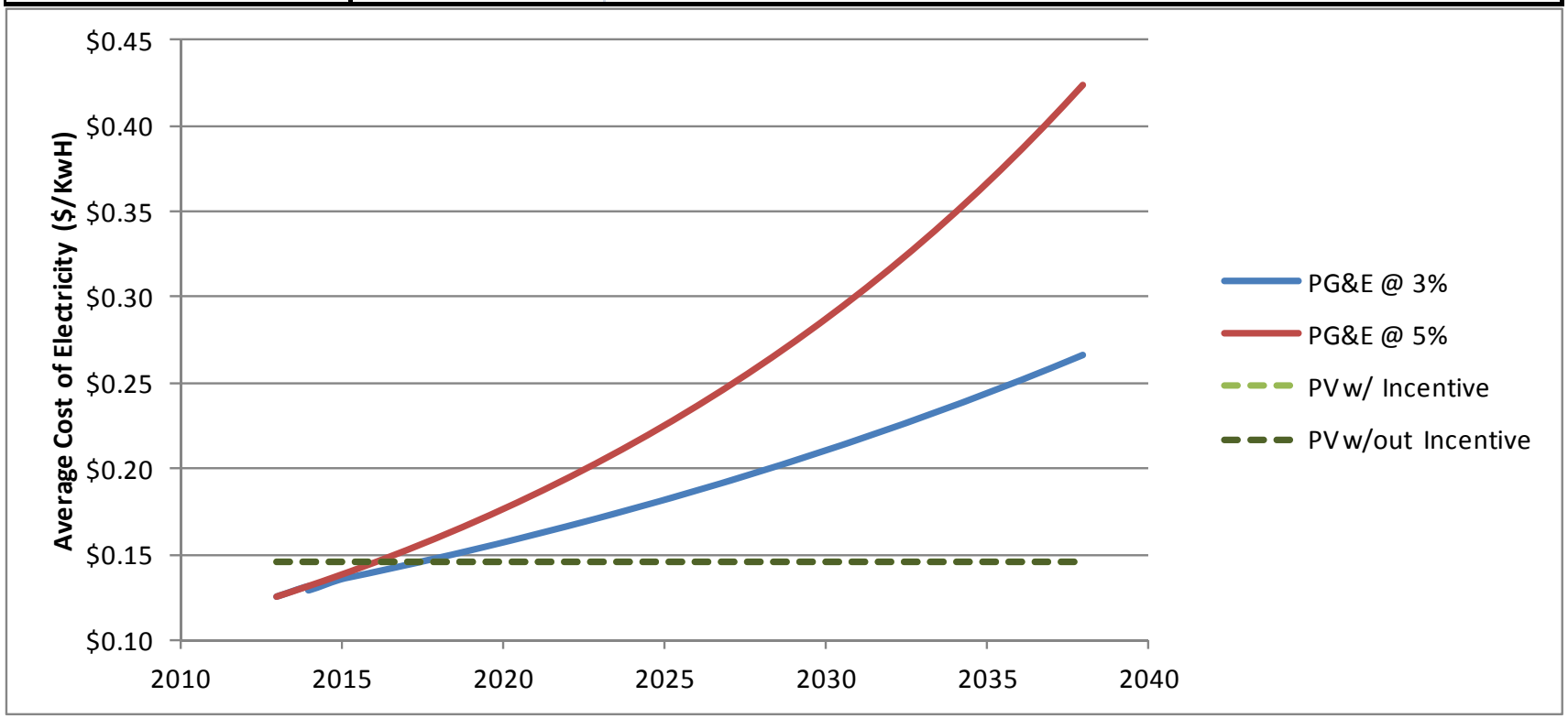
Notes / Assumptions:

1. Average Price for Natural Gas is $0.70/Therm.
2. Average Price for Electricity is $0.125/kWh.

Design Case Study

Reach for Net-Zero, Add PV

Year	$/kwh	PV $/kWh cost w/Incentives	PV $/kWh cost w/out Incentives
2013	$0.13	$0.15	$0.15
2037 (3%/Yr Increase)	$0.19		
2037 (5%/Yr Increase)	$0.24		
PV Array Size	575	kW	
PV Array Cost	$3,415,500.00	Without Incentives	
PV Array Cost	$3,401,125.00	With Incentives	



Design Case Study

LCC w/ Geo Fed Incentives (GeoTPA + PV)

LIFECYCLE COST ANALYSIS

BASED ON 30 YEAR ANALYSIS - 2013 to 2042

BASE Options	OPTIONS	Capital Costs ($)2013	Avg. Maint. Costs ($)	Avg. Repla. Costs ($)	Utility Costs ($)2013	Savings By Design Rebate ($)2013	Payback T24 Base (Years)	15 Year Cost of Ownership ($)2027	30 Year Cost of Ownership ($)2042	Energy Use Index (kBtu/sf-yr)
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1c	1a + Four Pipe VAV in Wet Labs	$3,000,000	$20,616	$43,779	$119,140	$25,545	8	$5,487,111	$12,154,637	116
2	Water Cooled Heat Recovery Chiller + Geothermal HX	$7,265,900	$20,616	$43,779	$5,885	$27,556	10	$4,337,460	$5,924,326	115
3a	Air Cooled Chillers + Condensing Boilers	$2,970,000	$17,444	$45,101	$94,772	$66,664	8	$5,386,663	$10,876,047	151
3b	3a + Four Pipe VAV in Wet Labs	$3,000,000	$17,444	$45,101	$93,745	$68,083	8	$5,393,083	$10,836,396	144
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Notes / Assumptions:

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2. Average Price for Electricity is $0.125/kWh.

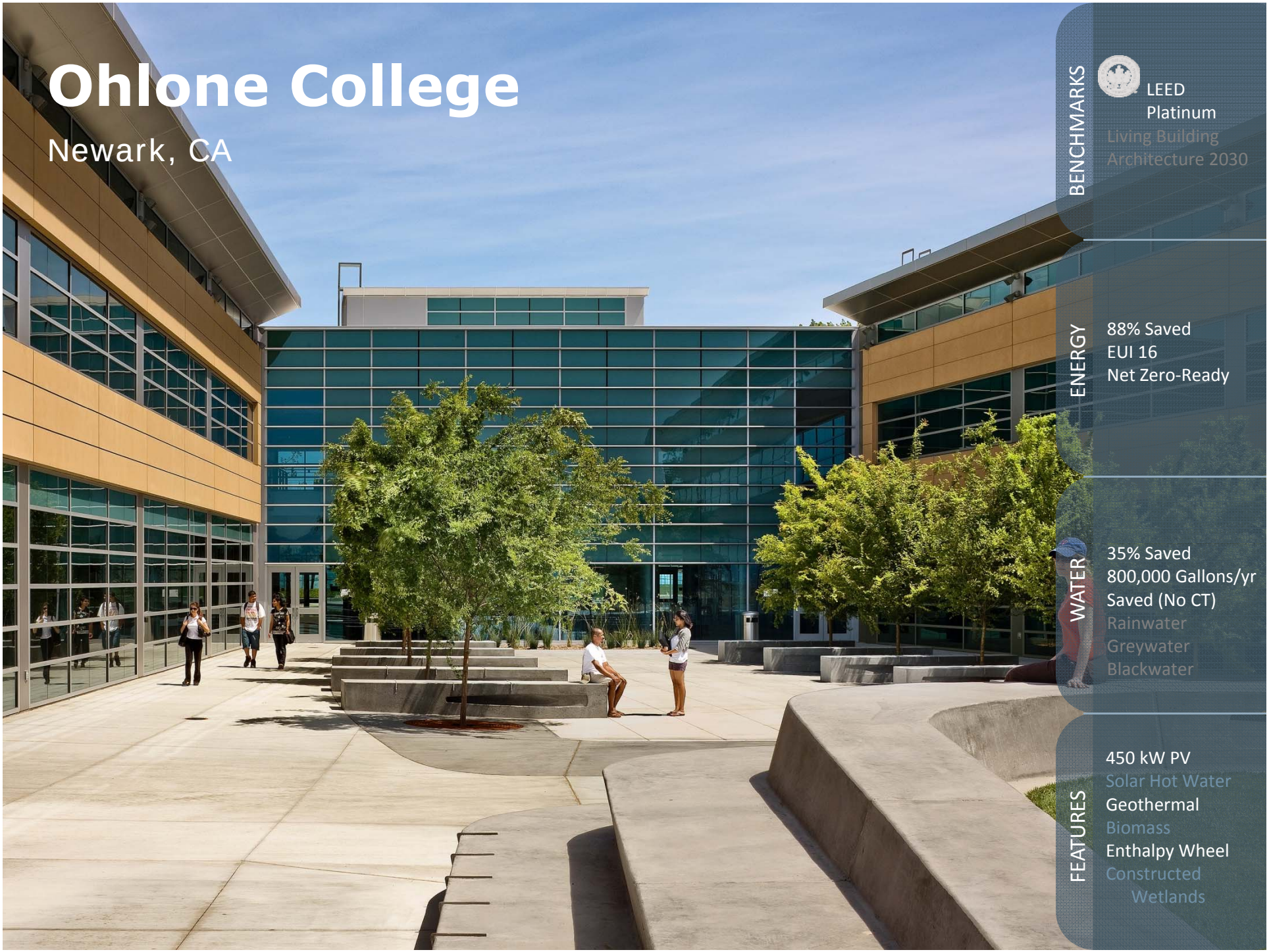
Geothermal Case Studies

Geothermal Case Studies

Higher Ed

Ohlone College

Newark, CA



BENCHMARKS

LEED
Platinum
Living Building
Architecture 2030

ENERGY

88% Saved
EUI 16
Net Zero-Ready

WATER

35% Saved
800,000 Gallons/yr
Saved (No CT)
Rainwater
Greywater
Blackwater

FEATURES

450 kW PV
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed
Wetlands

GEOTHERMAL GROUND COILS (SLINKY)

BENCHMARKS

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Net Zero-Ready

WATER

35% Saved
800,000 Gallons Sav
Rainwater
Greywater
Blackwater

FEATURES

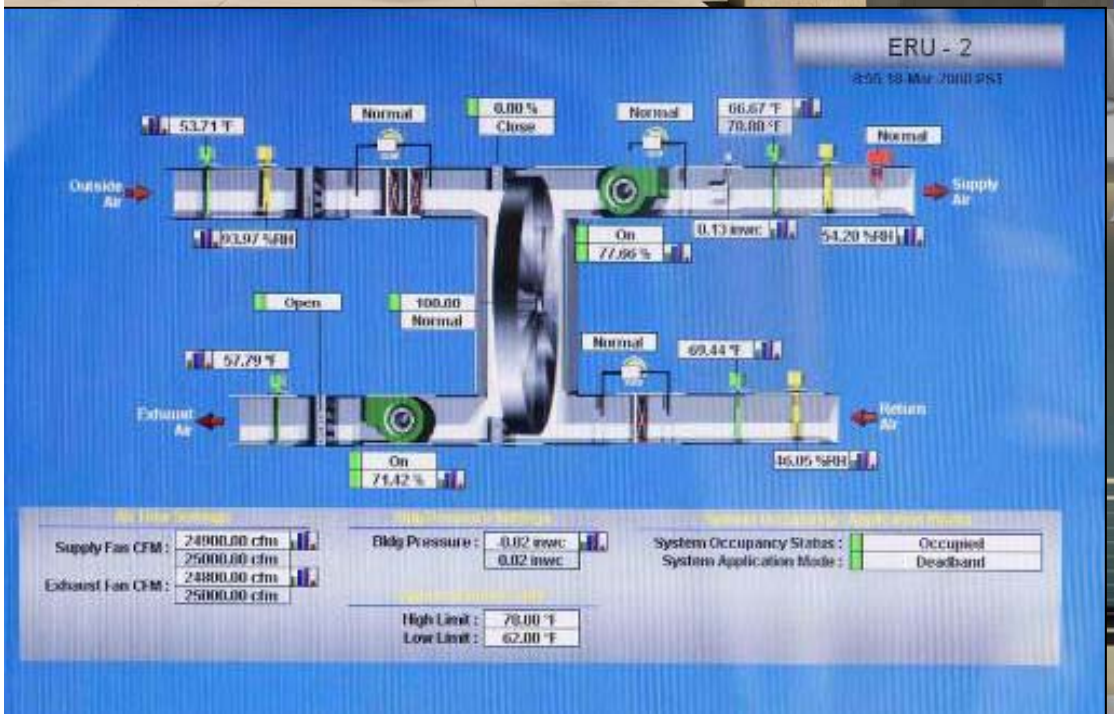
450 kW PV
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed
Wetlands

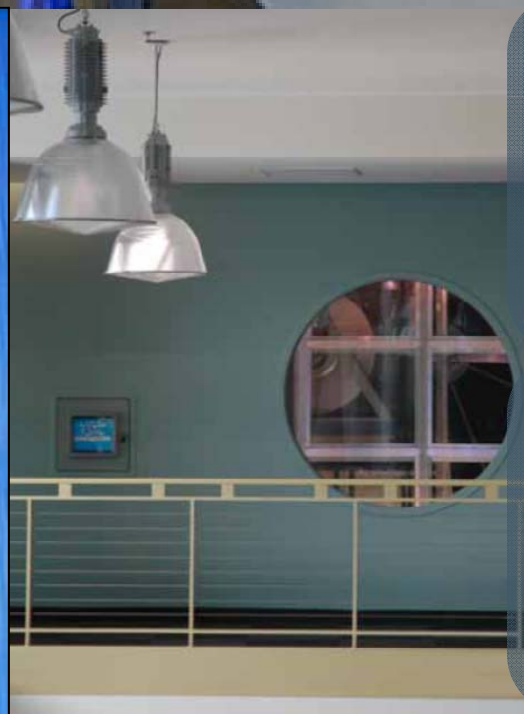
BENCHMARKS

LEED
Platinum
Living Building
Architecture 2030

ENERGY

88% Saved
EUI 16
Net Zero-Ready





WATER

35% Saved
800,000 Gallons Sav
Rainwater
Greywater
Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed
Wetlands

BENCHMARKS

LEED
Platinum
Living Building
Architecture 2030

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450 kW PV
Solar Hot Water
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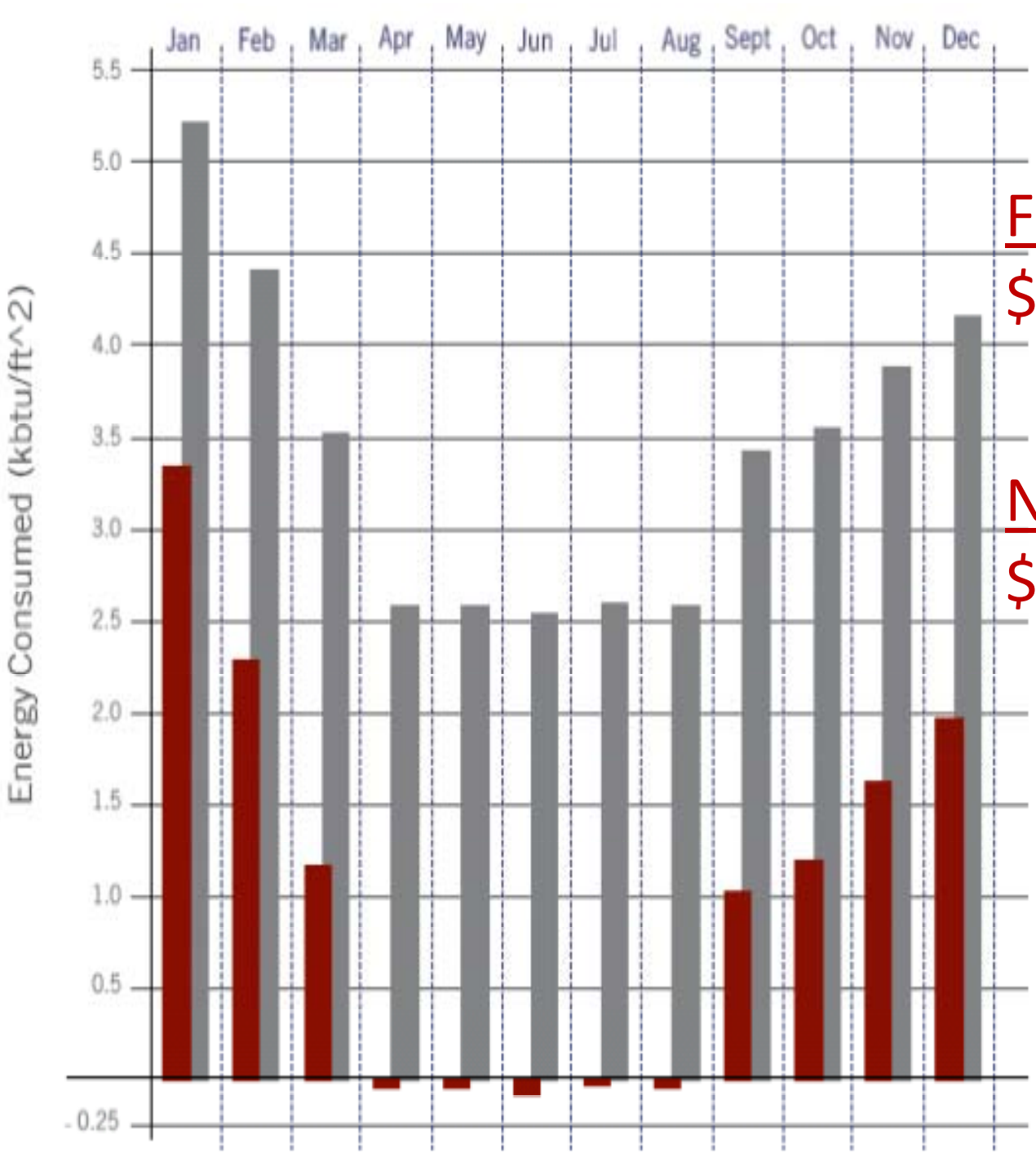
Constructed
Wetlands



Fremont
$3.50/SF-Yr

Newark
$0.48/SF-Yr

BENCHMARKS
- LEED Platinum
- Living Building Architecture 2030

ENERGY
- 88% Saved
- EUI 16
- Net Zero-Ready

WATER
- 35% Saved
- 800,000 Gallons Sav
- Rainwater
- Greywater
- Blackwater

FEATURES
- PV
- Solar Hot Water
- Geothermal
- Biomass
- Enthalpy Wheel
- Constructed Wetlands

College Of Marin: KTD Campus

Kentfield, CA

BENCHMARKS

LEED
Living Building
Architecture 2030

ENERGY

+30% Saved
EUI
Net Zero

WATER

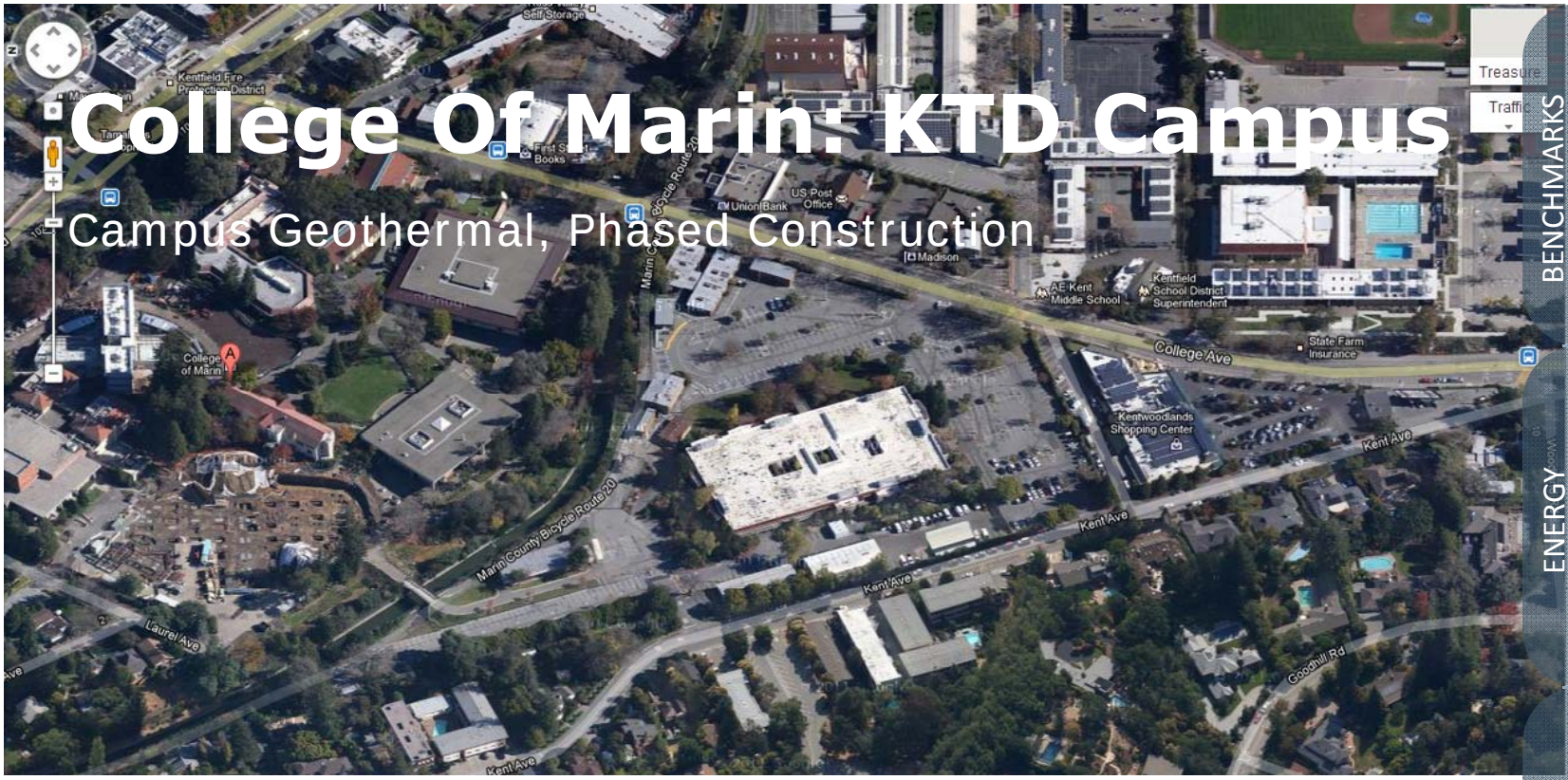
% Saved
1.6 Million Gallons/y
Saved (No CT)
Rainwater
Greywater
Blackwater

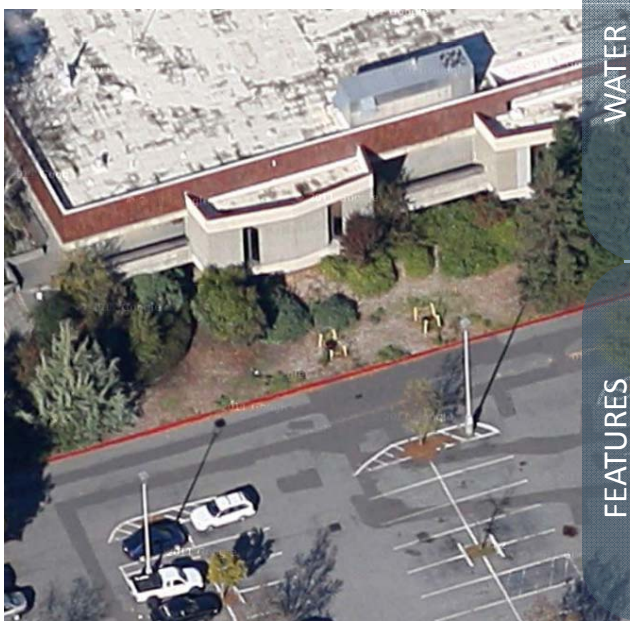
FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed
Wetlands

College Of Marin: KTD Campus

Campus Geothermal, Phased Construction





BENCHMARKS

LEED
Living Building
Architecture 2030

ENERGY

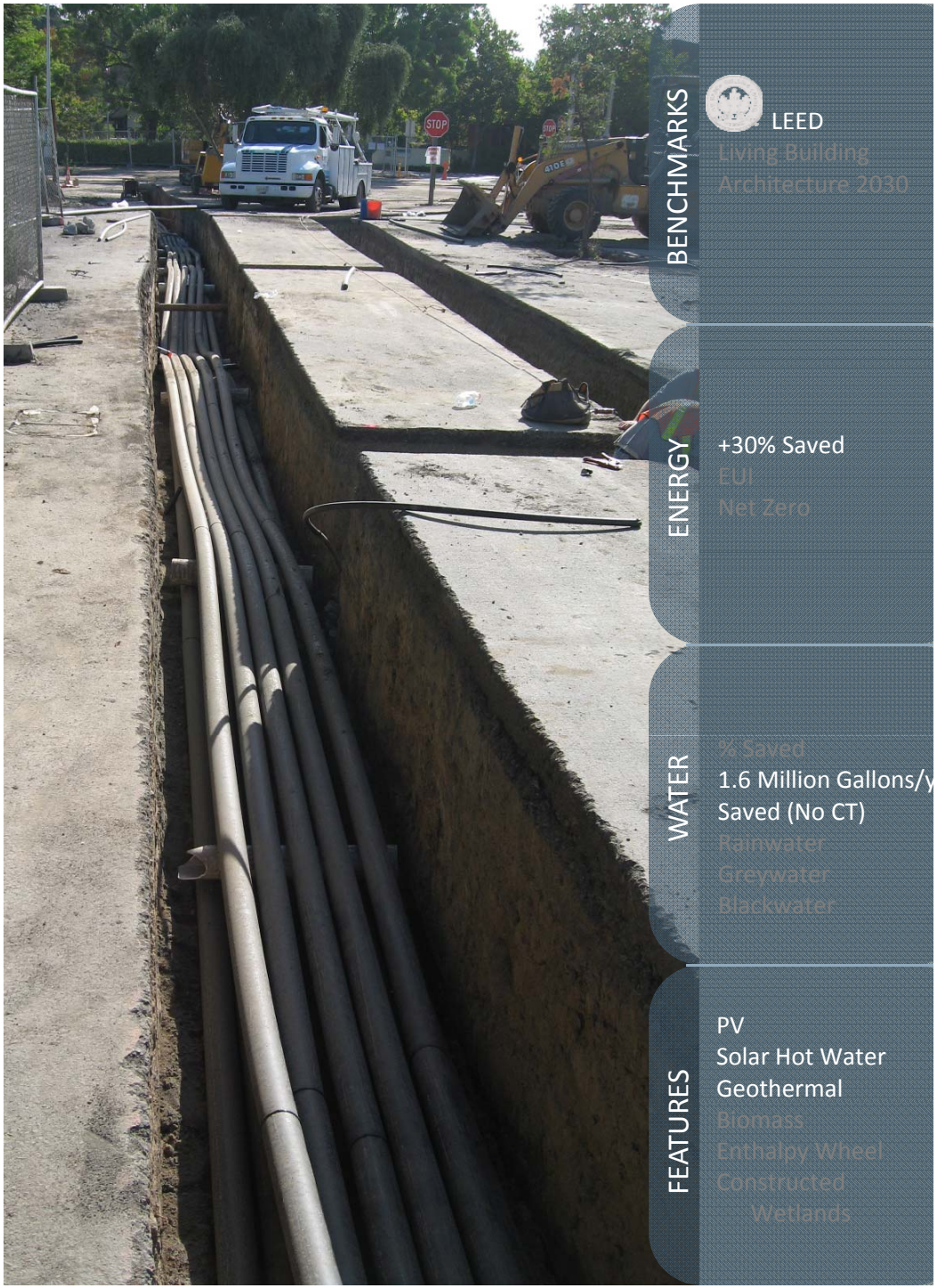
+30% Saved
EUI
Net Zero

WATER

% Saved
1.6 Million Gallons/y
Saved (No CT)
Rainwater
Greywater
Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed
Wetlands



BENCHMARKS

LEED
Living Building
Architecture 2030

ENERGY

+30% Saved
EUI
Net Zero

WATER

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1.6 Million Gallons/y
Saved (No CT)
Rainwater
Greywater
Blackwater

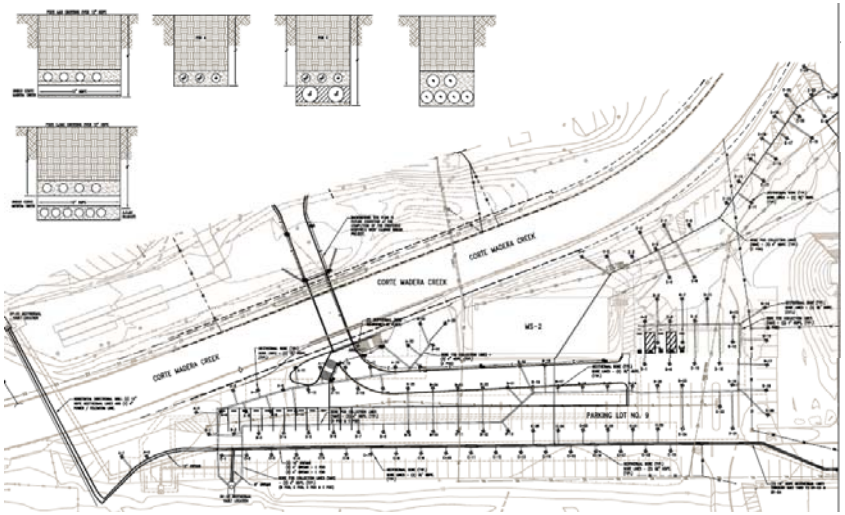
FEATURES

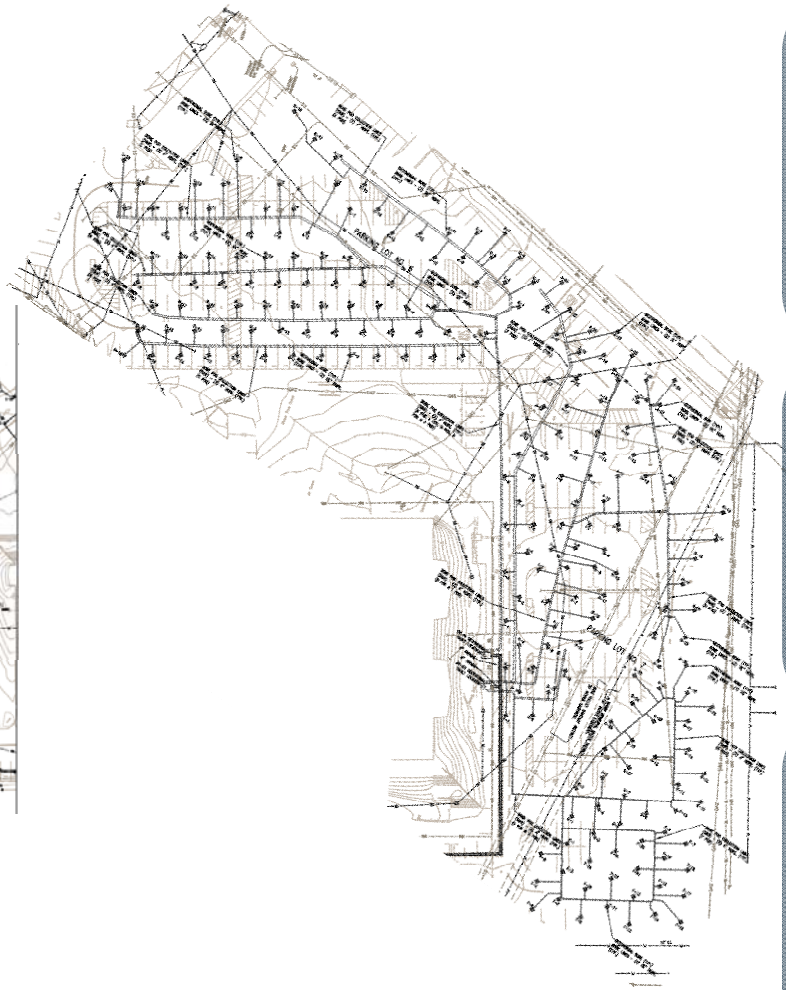
PV
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed
Wetlands

College Of Marin: KTD Campus

Vertical Closed Loop

- 340 Bores
- 380’ Deep
- 3 Valve Vaults
- 650 Ton Capacity





BENCHMARKS

LEED
Living Building
Architecture 2030

ENERGY

+30% Saved
EUI
Net Zero

WATER

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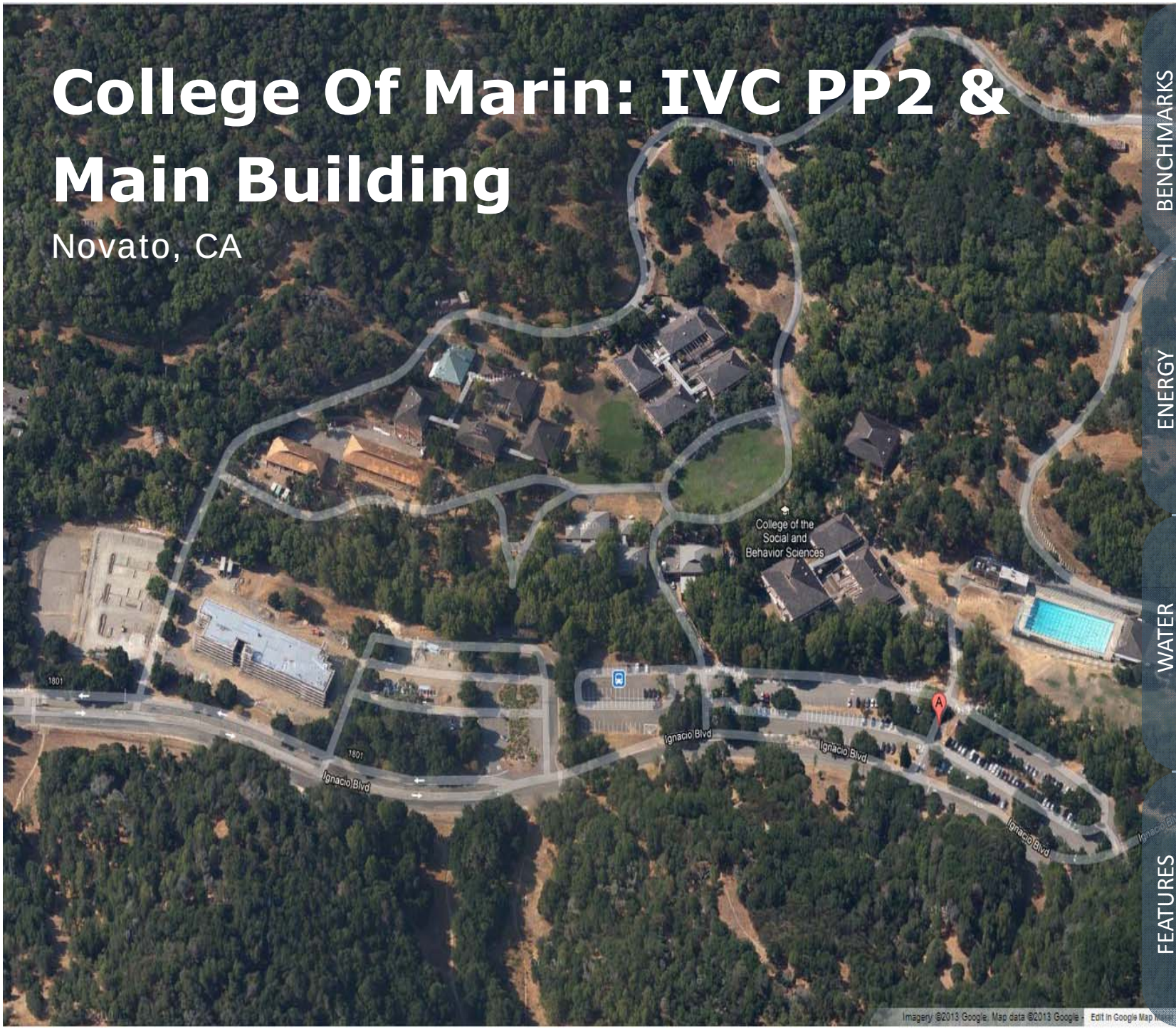
1.6 Million Gallons/y
Saved (No CT)
Rainwater
Greywater
Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed
Wetlands

College Of Marin: IVC PP2 & Main Building

Novato, CA



BENCHMARKS

LEED Gold
Living Building
Architecture 2030

ENERGY

+30% Saved
EUI
Net Zero

WATER

% Saved
850,000 Gallons/yr Saved (No CT)
Rainwater
Greywater
Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed Wetlands

College Of Marin: PP 2

Simpler System, Less Maintenance, Energy & Water Efficiency

BENCHMARKS

LEED Gold
Living Building
Architecture 2030

ENERGY

+30% Saved
EUI
Net Zero

WATER

% Saved
850,000 Gallons/yr Saved (No CT)
Rainwater
Greywater
Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed Wetlands

College Of Marin: PP 2

Power Plant Replacement

BENCHMARKS

- LEED Gold
- Living Building
- Architecture 2030

ENERGY

- +30% Saved
- EUI
- Net Zero

WATER

- % Saved
- 850,000 Gallons/yr Saved (No CT)
- Rainwater
- Greywater
- Blackwater

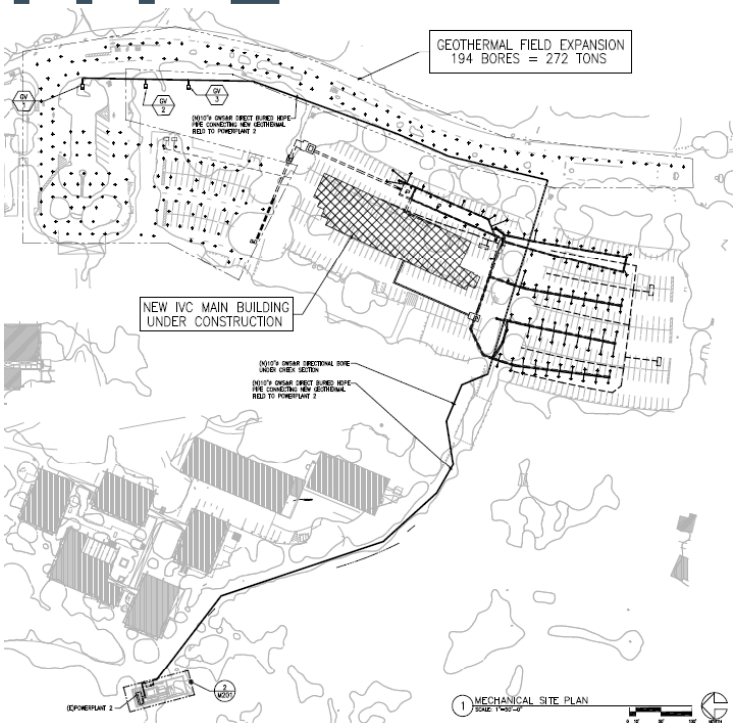
FEATURES

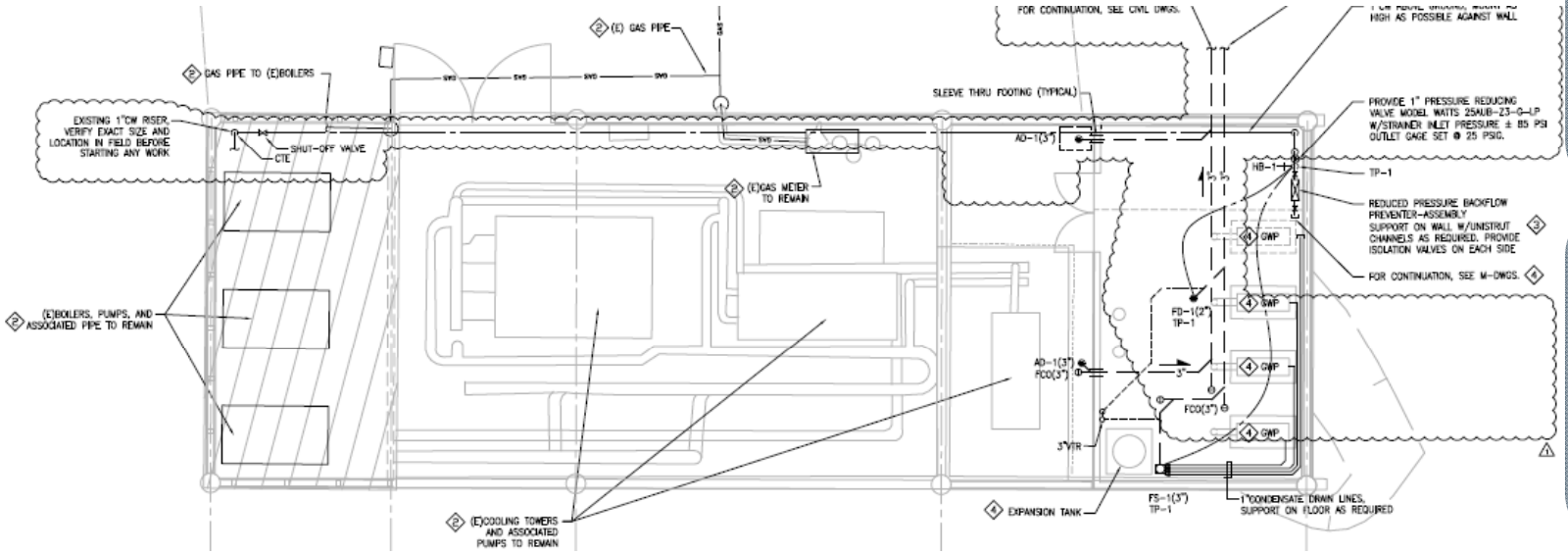
- PV
- Solar Hot Water
- Geothermal
- Biomass
- Enthalpy Wheel
- Constructed Wetlands

College Of Marin: PP 2

Vertical Closed Loop Expansion

- 195 Bores
- 250’ Deep
- 3 Valve Vaults
- 300 Ton Capacity
- Eliminated Boilers
- Eliminated Cooling Towers





BENCHMARKS
- LEED Gold
- Living Building
- Architecture 2030

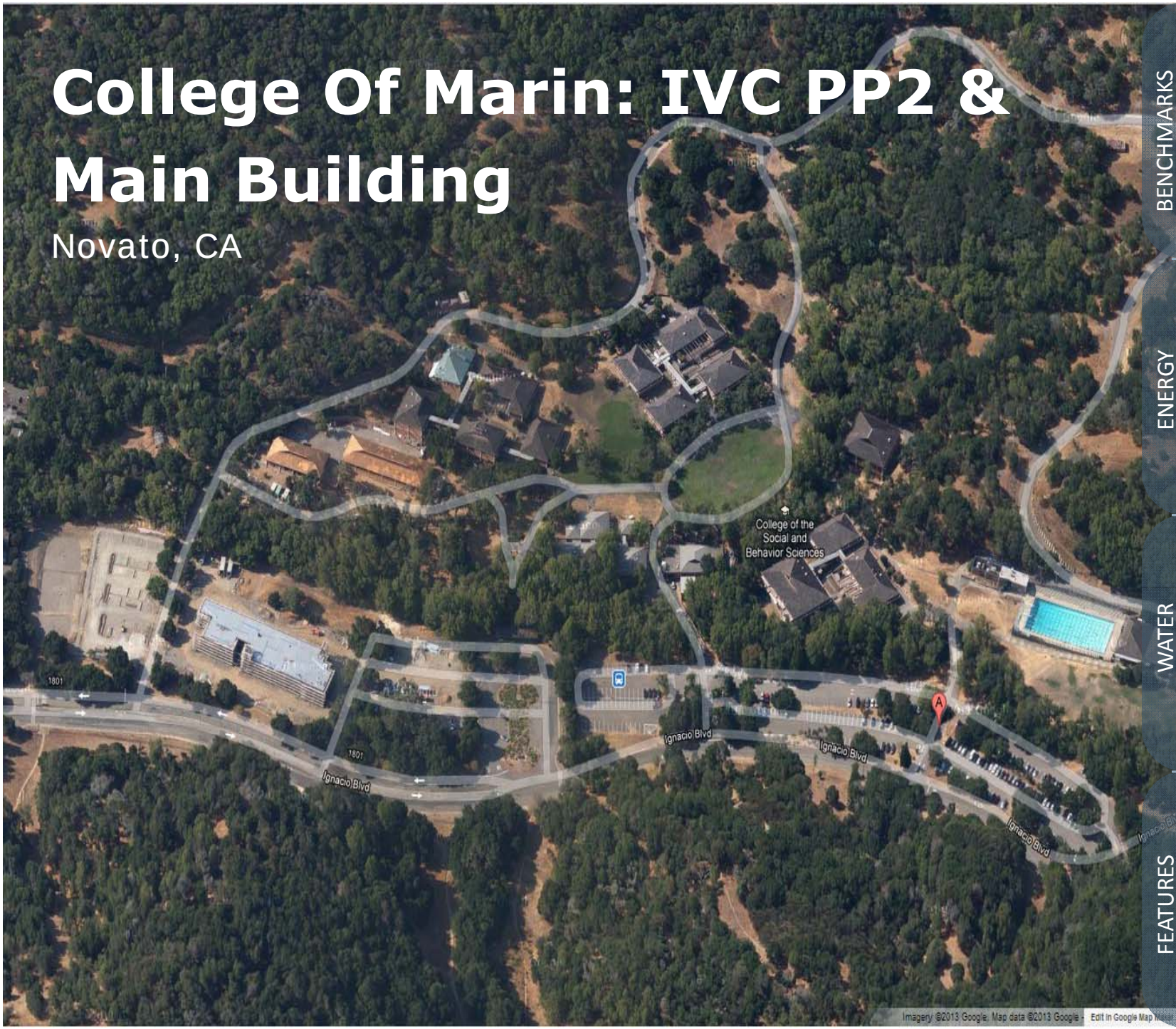
ENERGY
- +30% Saved
- EUI
- Net Zero

WATER
- % Saved
- 850,000 Gallons/yr Saved (No CT)
- Rainwater
- Greywater
- Blackwater

FEATURES
- PV
- Solar Hot Water
- Geothermal
- Biomass
- Enthalpy Wheel
- Constructed Wetlands

College Of Marin: IVC PP2 & Main Building

Novato, CA



BENCHMARKS

LEED Gold
Living Building
Architecture 2030

ENERGY

+30% Saved
EUI
Net Zero

WATER

% Saved
850,000 Gallons/yr Saved (No CT)
Rainwater
Greywater
Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed Wetlands

College Of Marin: IVC Main Bldg

Student Services and Dental Labs

BENCHMARKS

- LEED Gold
- Living Building
- Architecture 2030

ENERGY

- +30% Saved
- EUI
- Net Zero

WATER

- % Saved
- 300,000 Gallons/yr Saved (No CT)
- Rainwater
- Greywater
- Blackwater

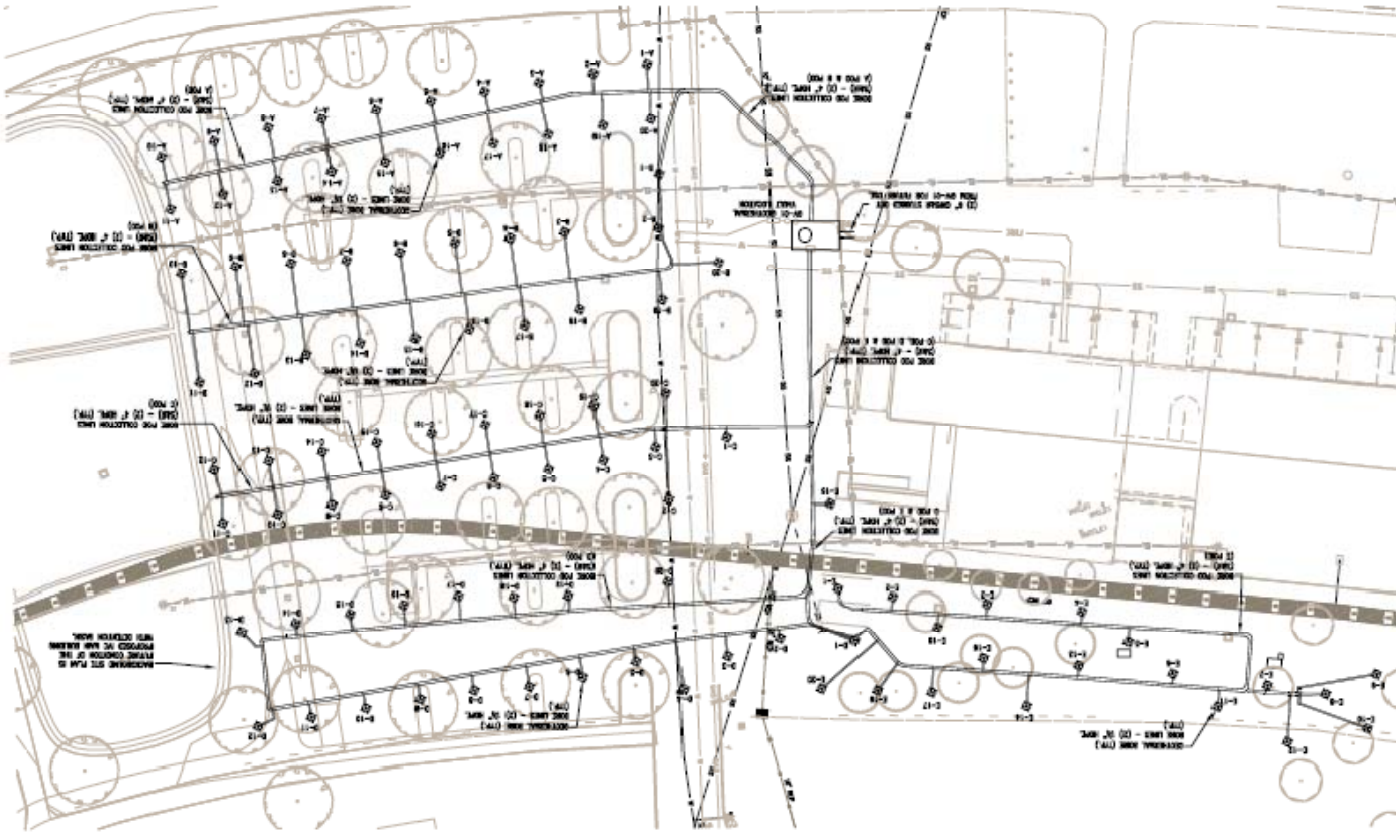
FEATURES

- PV
- Solar Hot Water
- Geothermal
- Biomass
- Enthalpy Wheel
- Constructed Wetlands

College Of Marin: IVC Main Bldg

Vertical Closed Loop

- 100 Bores
- 250’ Deep
- 1 Valve Vaults
- 150 Ton Capacity



BENCHMARKS

LEED Gold
Living Building
Architecture 2030

ENERGY

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EUI
Net Zero

WATER

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300,000 Gallons/yr Saved (No CT)
Rainwater
Greywater
Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed Wetlands

SRJC: Student Services

Santa Rosa, CA

BENCHMARKS

LEED Platinum
Living Building
Architecture 2030

ENERGY

+50% Saved
EUI
Net Zero

WATER

% Saved
850,000 Gallons/yr Saved (No CT)
Rainwater
Greywater
Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed Wetlands

SRJC: Student Services

Student Services Building (Bertolini Student Center)

BENCHMARKS

- LEED Platinum
- Living Building
- Architecture 2030

ENERGY

- +50% Saved
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WATER

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- 850,000 Gallons/yr Saved (No CT)
- Rainwater
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- Blackwater

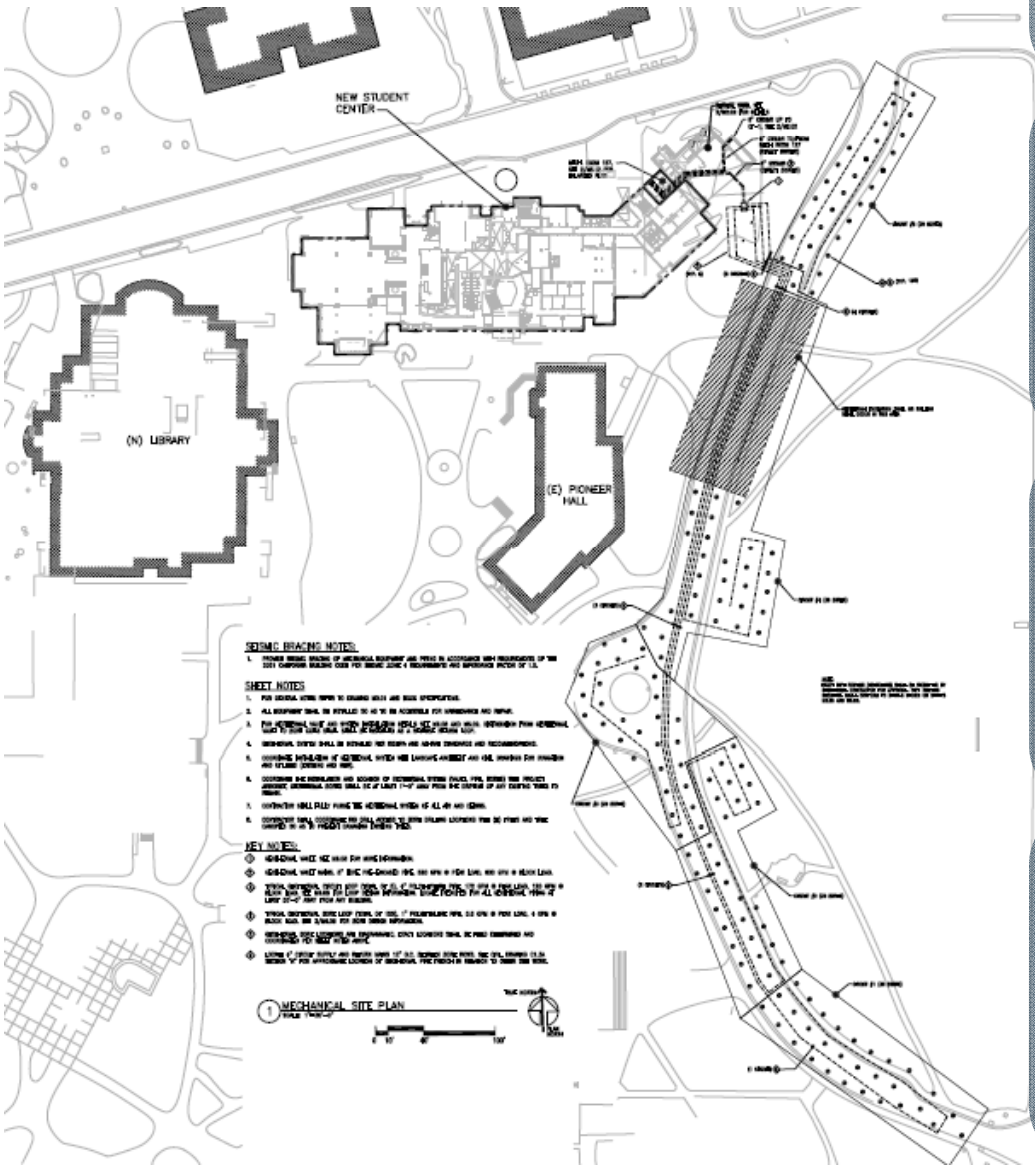
FEATURES

- PV
- Solar Hot Water
- Geothermal
- Biomass
- Enthalpy Wheel
- Constructed Wetlands

SRJC: Student Services

Vertical Closed Loop Expansion

- 150 Bores
- 250’ Deep
- 1 Valve Vault
- 230 Ton Capacity



BENCHMARKS

LEED Platinum
Living Building
Architecture 2030

ENERGY

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EUI
Net Zero

WATER

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FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed Wetlands

Geothermal Case Studies

Corporate HQ

The Bullitt Center

Seattle, WA

Architect: Miller|Hull

BENCHMARKS

Living Building
Architecture 2030

ENERGY

70% Saved
16 EUI
Net Zero

WATER

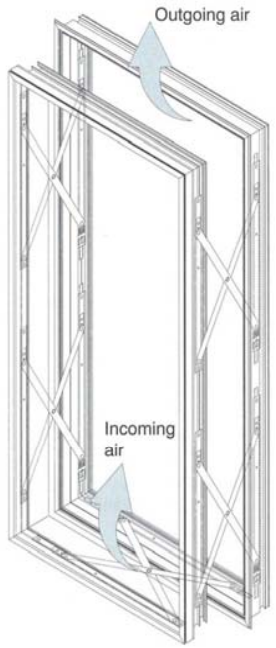
100% Saved
Rainwater
Greywater

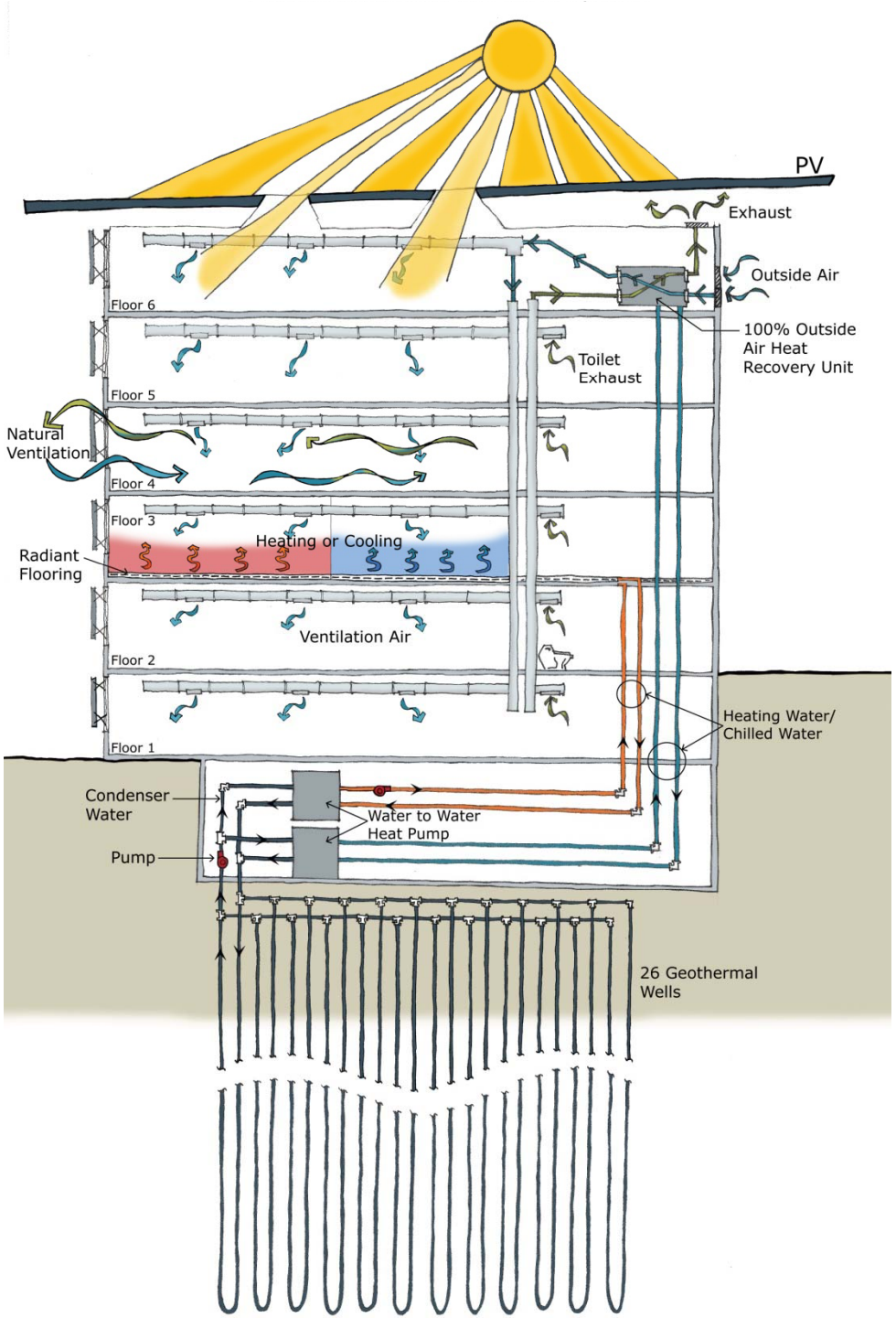
FEATURES

PV

Geothermal

Constructed
Wetlands





BENCHMARKS

Living Building
Architecture 2030

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70% Saved
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Net Zero

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Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Wind
Constructed Wetlands

BENCHMARKS

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FEATURES

PV

Geothermal

Constructed
Wetlands

BENCHMARKS

~~LEED~~

Living Building

Architecture 2030

ENERGY

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Net Zero

WATER

100% Saved

Rainwater

Greywater

~~Blackwater~~

FEATURES

PV

~~Solar Hot Water~~

Geothermal

~~Biomass~~

~~Wind~~

Constructed Wetlands

$6.2 Million

A typical building of this size has an **Energy Use Intensity of 72** kBtu/ft²/year. A PV array with an area of **64,348 ft²** is required to meet its energy needs.

$4.4 Million

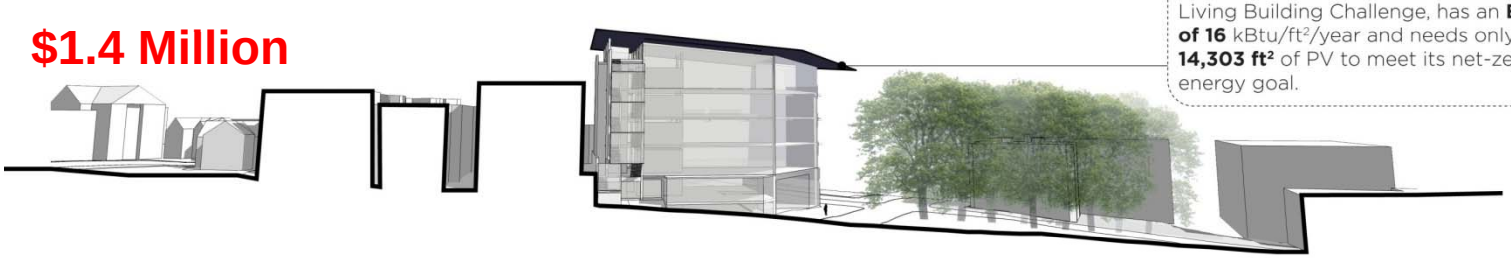
A building of this size meeting Seattle Energy Code has an **EUI of 51** kBtu/ft²/year, requiring a PV array with an area of **44,752 ft²** to meet its energy needs.

$2.5 Million

A LEED Platinum certified building of this size has an **EUI of 32** kBtu/ft²/year, requiring a PV array with an area of **28,599 ft²** to meet its energy needs.

$1.4 Million

The proposed building, meeting the Living Building Challenge, has an **EUI of 16** kBtu/ft²/year and needs only **14,303 ft²** of PV to meet its net-zero energy goal.



BENCHMARKS

~~LEED~~
Living Building
Architecture 2030

ENERGY

70% Saved
16 EUI
Net Zero

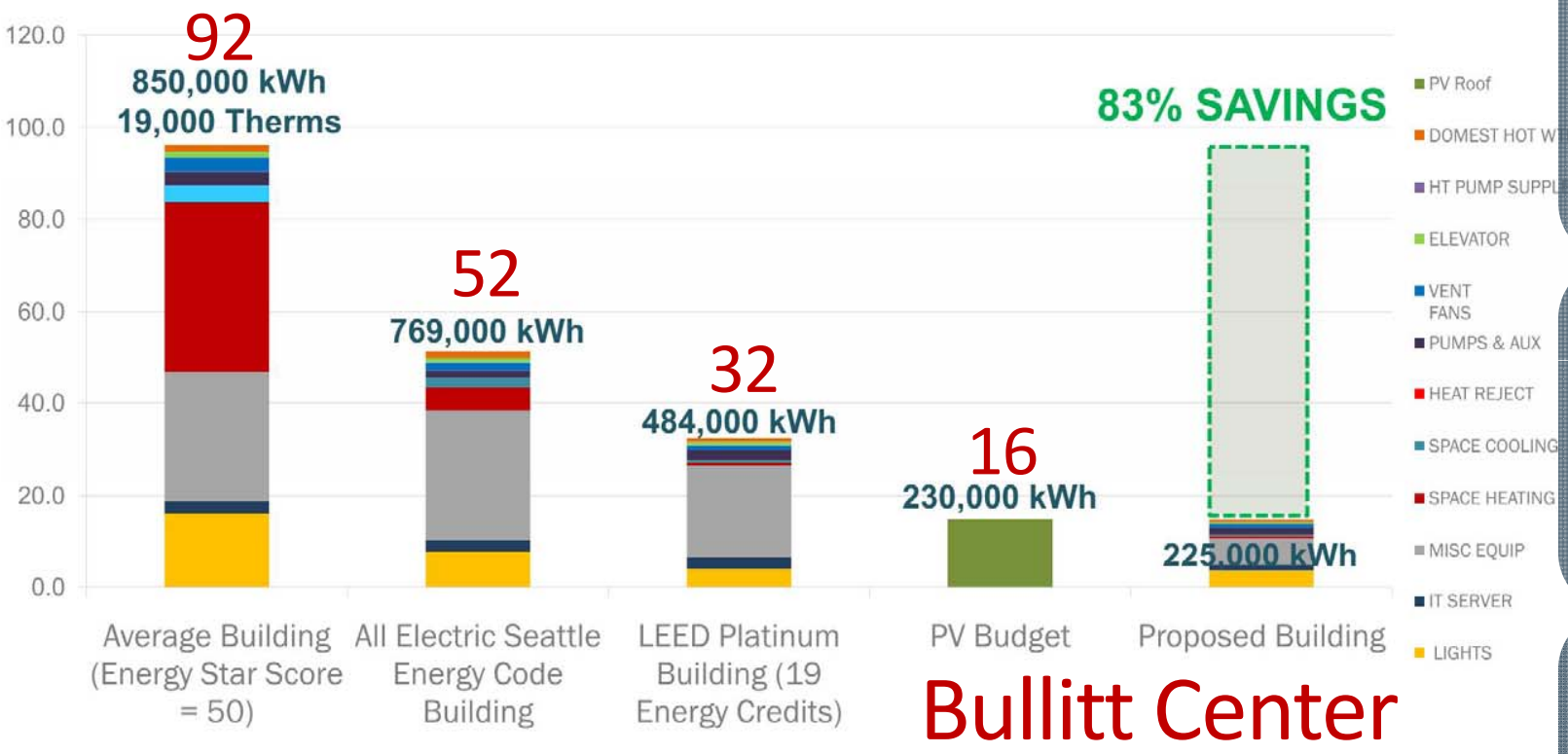
WATER

100% Saved
Rainwater
Greywater
~~Blackwater~~

FEATURES

PV
~~Solar Hot Water~~
Geothermal
~~Biomass~~
~~Wind~~
Constructed
Wetlands

Energy Use | Solar Budget



Bullitt Center

BENCHMARKS
- Living Building
- Architecture 2030

ENERGY
- 70% Saved
- 16 EUI
- Net Zero

WATER
- 100% Saved
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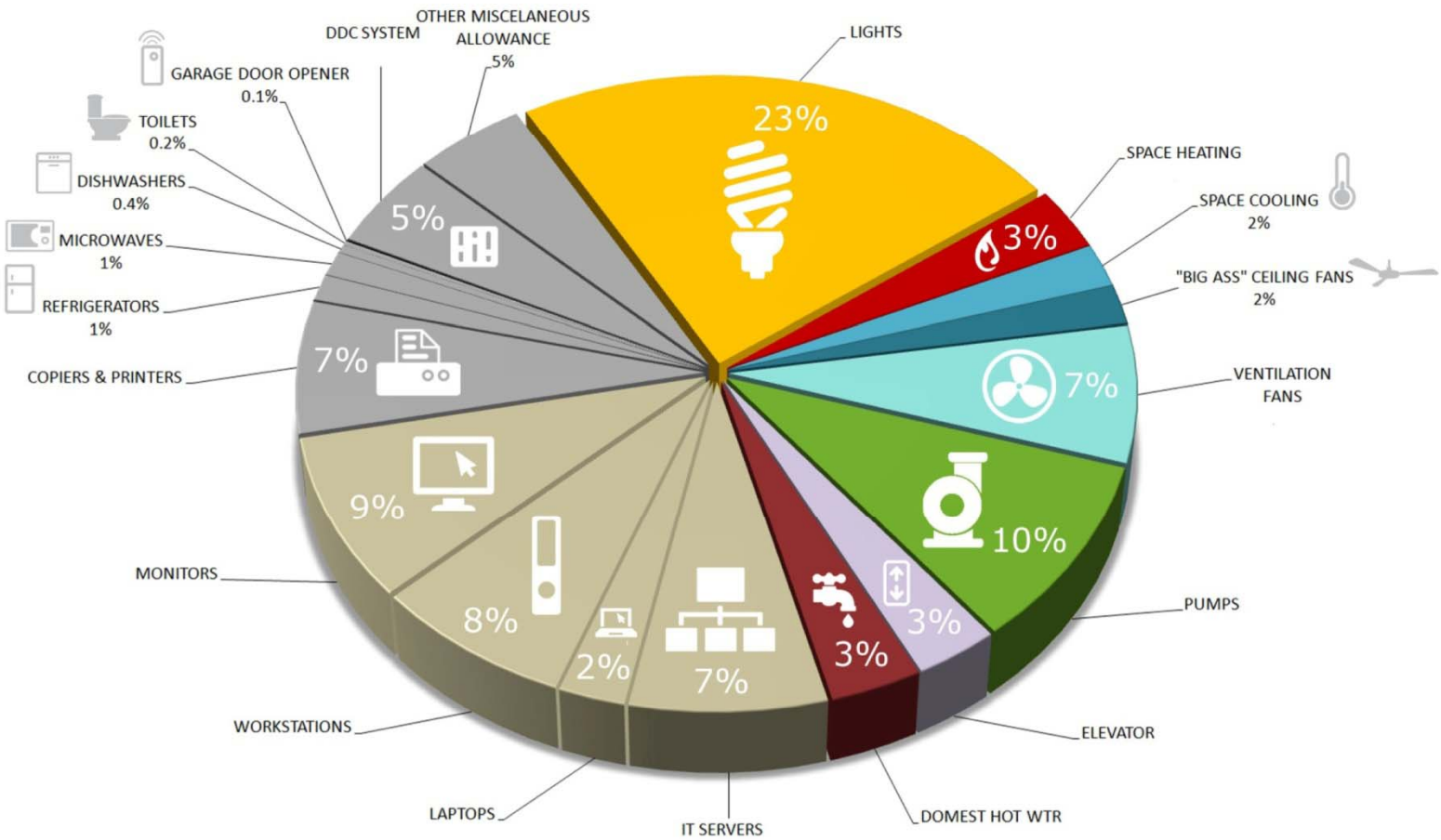
FEATURES
- PV
- Solar Hot Water
- Geothermal
- Biomass
- Wind
- Constructed Wetlands

ENERGY USE



BENCHMARKS

~~LEED~~
Living Building
Architecture 2030

ENERGY

70% Saved
17 EUI
Net Zero

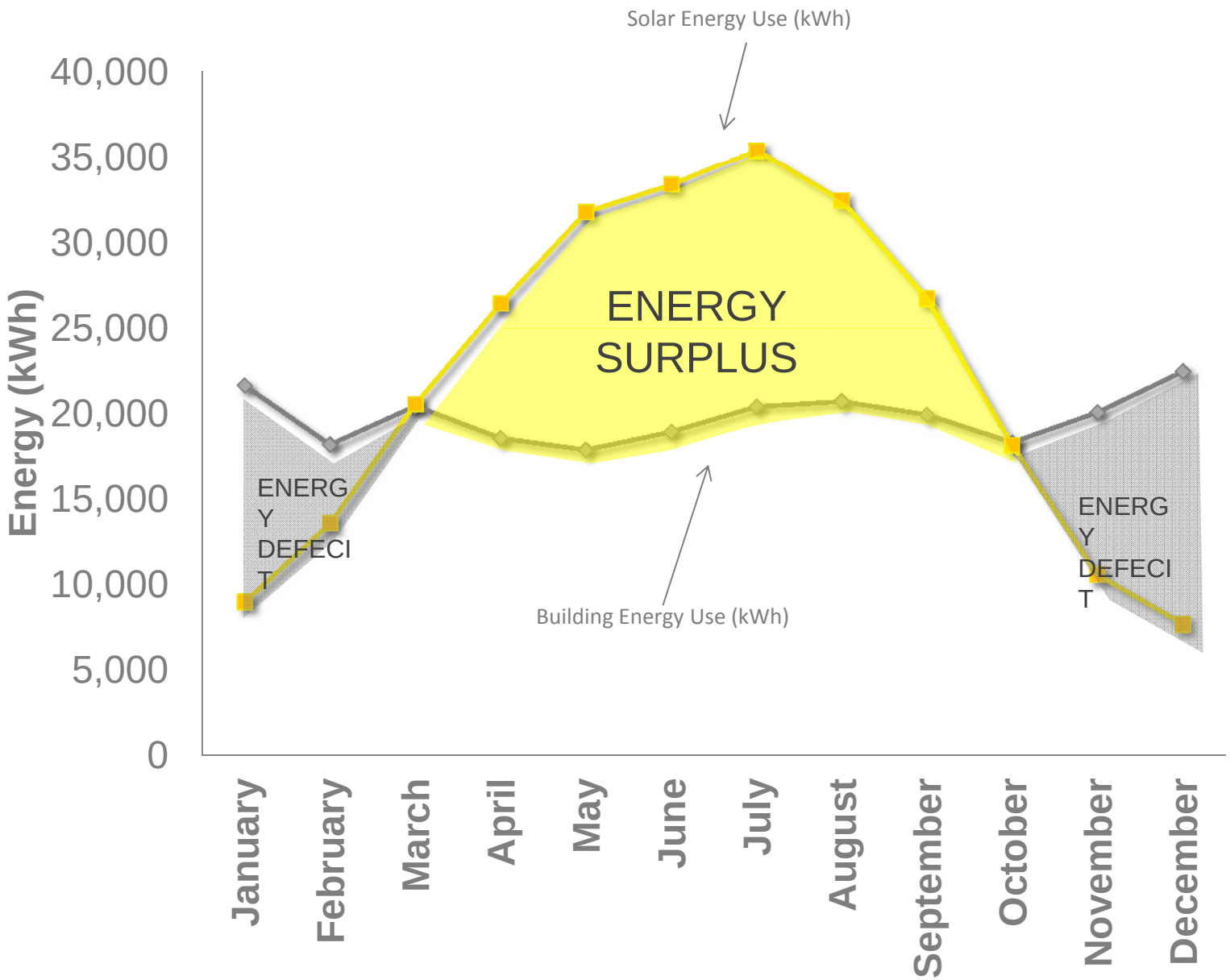
WATER

100% Saved
Rainwater
Greywater
~~Blackwater~~

FEATURES

PV
~~Solar Hot Water~~
Geothermal
~~Biomass~~
~~Wind~~
Constructed
Wetlands

ENERGY USE | SOLAR BUDGET



BENCHMARKS

- LEED
- Living Building
- Architecture 2030

ENERGY

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- 17 EUI
- Net Zero

WATER

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- Rainwater
- Greywater
- Blackwater

FEATURES

- PV
- Solar Hot Water
- Geothermal
- Biogas
- Wind
- Constructed Wetlands

Phoenix R-200

Courtesy: 2020 Engineering

Port of Portland HQP2

Portland, OR

Architect: ZGF

BENCHMARKS

LEED
Platinum
Living Building
Architecture 2030

ENERGY

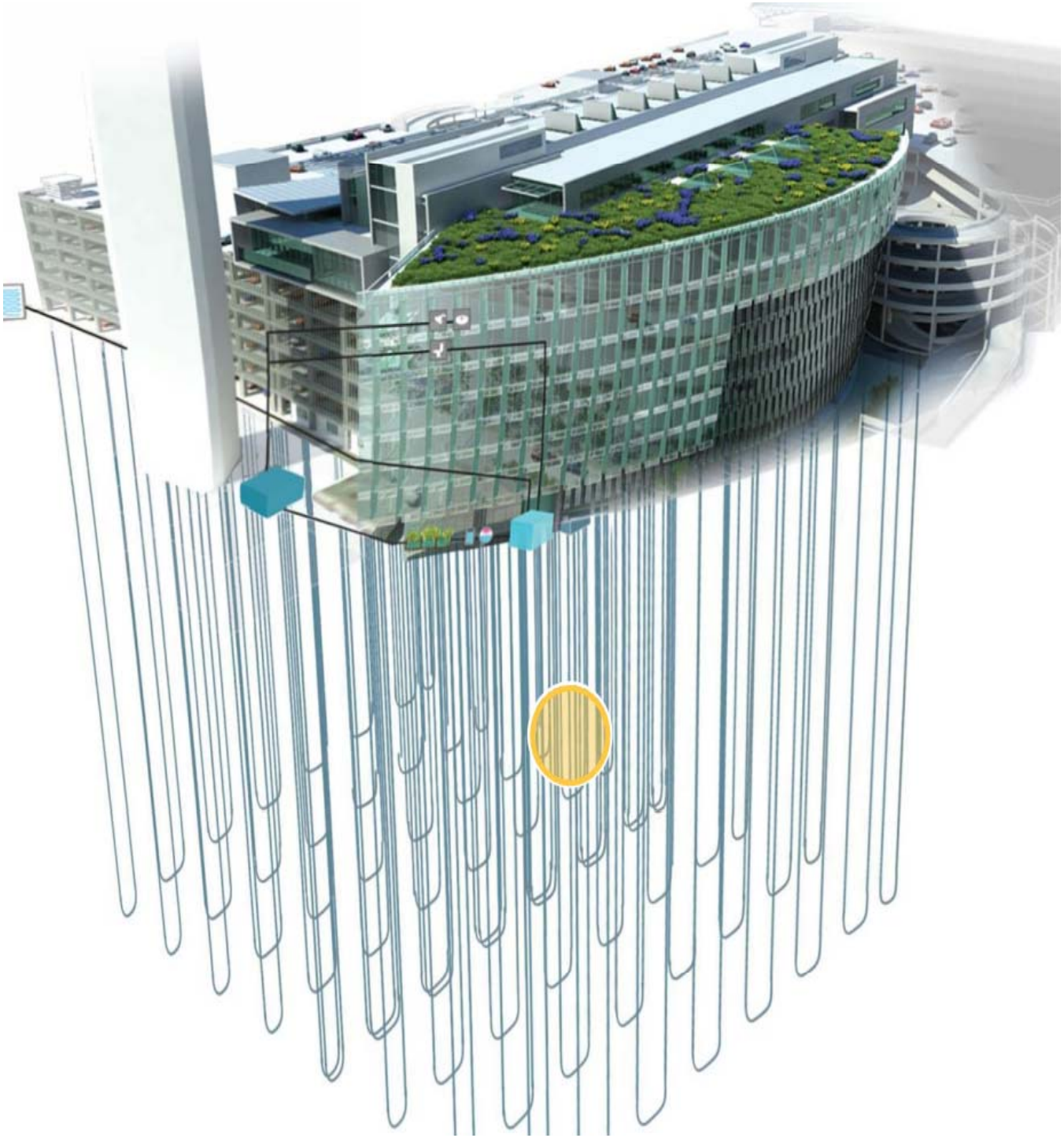
51% Saved
42 EUI
Net Zero

WATER

80% Saved
Rainwater
Greywater
Blackwater

FEATURES

Radiant Heating + Cooling
Solar Hot Water
Geothermal
Living Machine
Wind



BENCHMARKS

LEED Platinum
Living Building
Architecture 2030

ENERGY

51% Saved
42 EUI
Net Zero

WATER

80% Saved
Rainwater
Greywater
Blackwater

FEATURES

Radiant Heating + Cooling
Solar Hot Water
Geothermal
Living Machine
Wind
Reconstructed Wetlands

The Columbian Headquarters

Vancouver, WA

Architect: GBD

BENCHMARKS

LEED Gold
Living Building
Architecture 2030

ENERGY

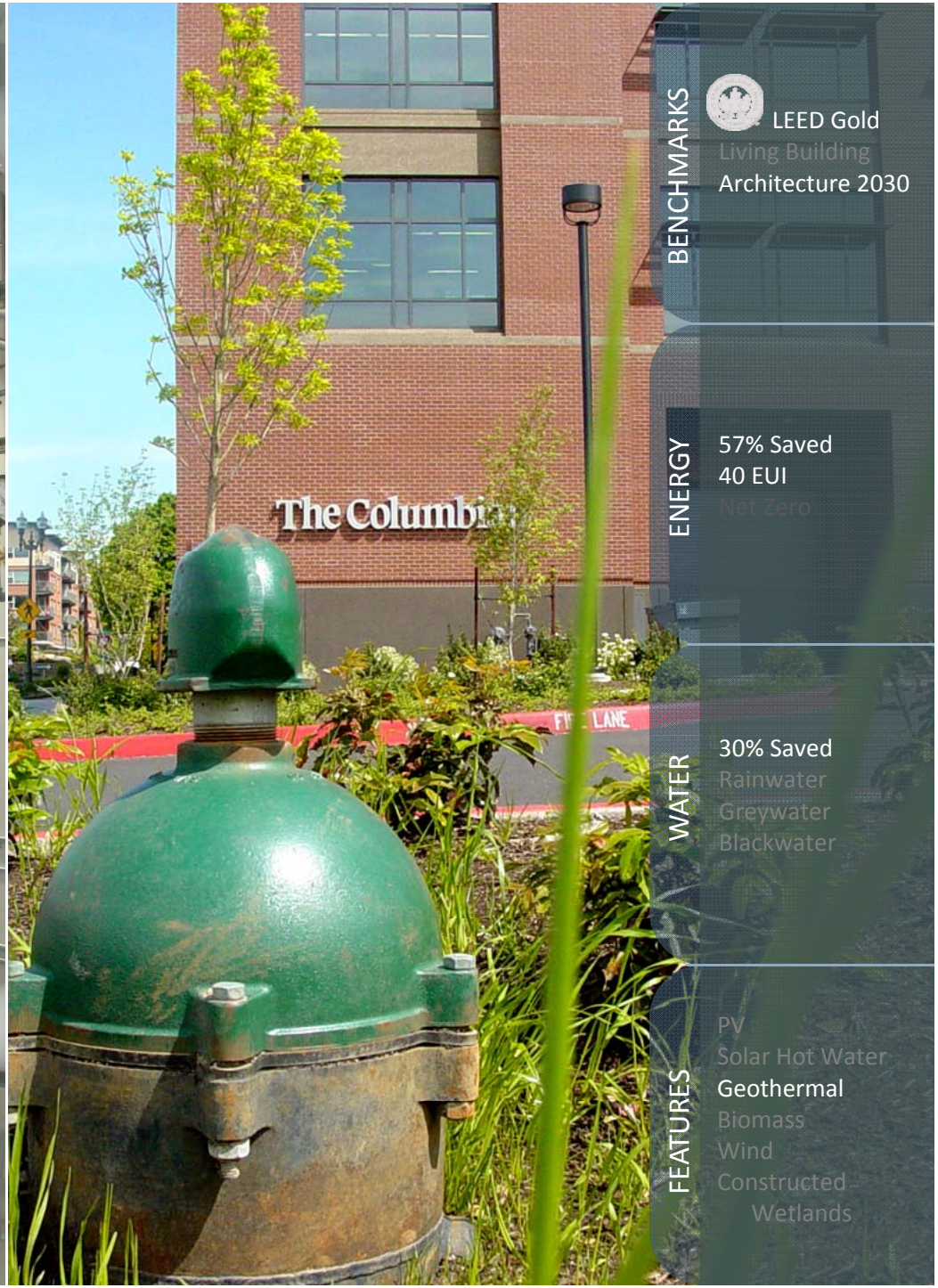
57% Saved
40 EUI
Net Zero

WATER

30% Saved
Rainwater
Greywater
Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Wind
Constructed Wetlands



BENCHMARKS

LEED Gold
Living Building
Architecture 2030

ENERGY

57% Saved
40 EUI
Net Zero

WATER

30% Saved
Rainwater
Greywater
Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Wind
Constructed
Wetlands

Geothermal Case Studies

Laboratories

Buck Institute

Novato, CA

BENCHMARKS

LEED Gold
Living Building
Architecture 2030

ENERGY

40% Saved
Net Zero

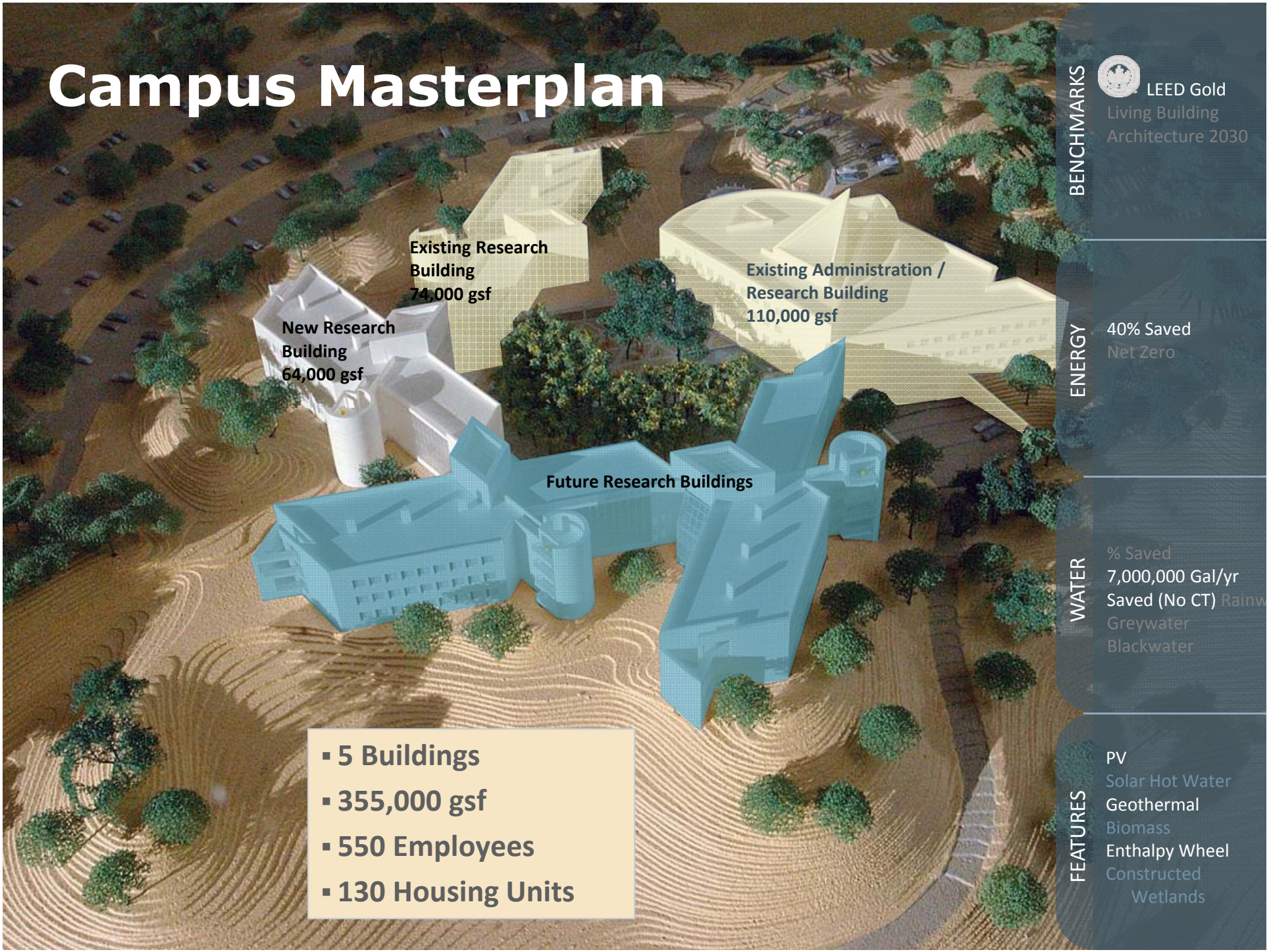
WATER

% Saved
7,000,000 Gal/yr
Saved (No CT) Rainw
Greywater
Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed
Wetlands

Campus Masterplan



- 5 Buildings
- 355,000 gsf
- 550 Employees
- 130 Housing Units

BENCHMARKS

LEED Gold
Living Building
Architecture 2030

ENERGY

40% Saved
Net Zero

WATER

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7,000,000 Gal/yr
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Blackwater

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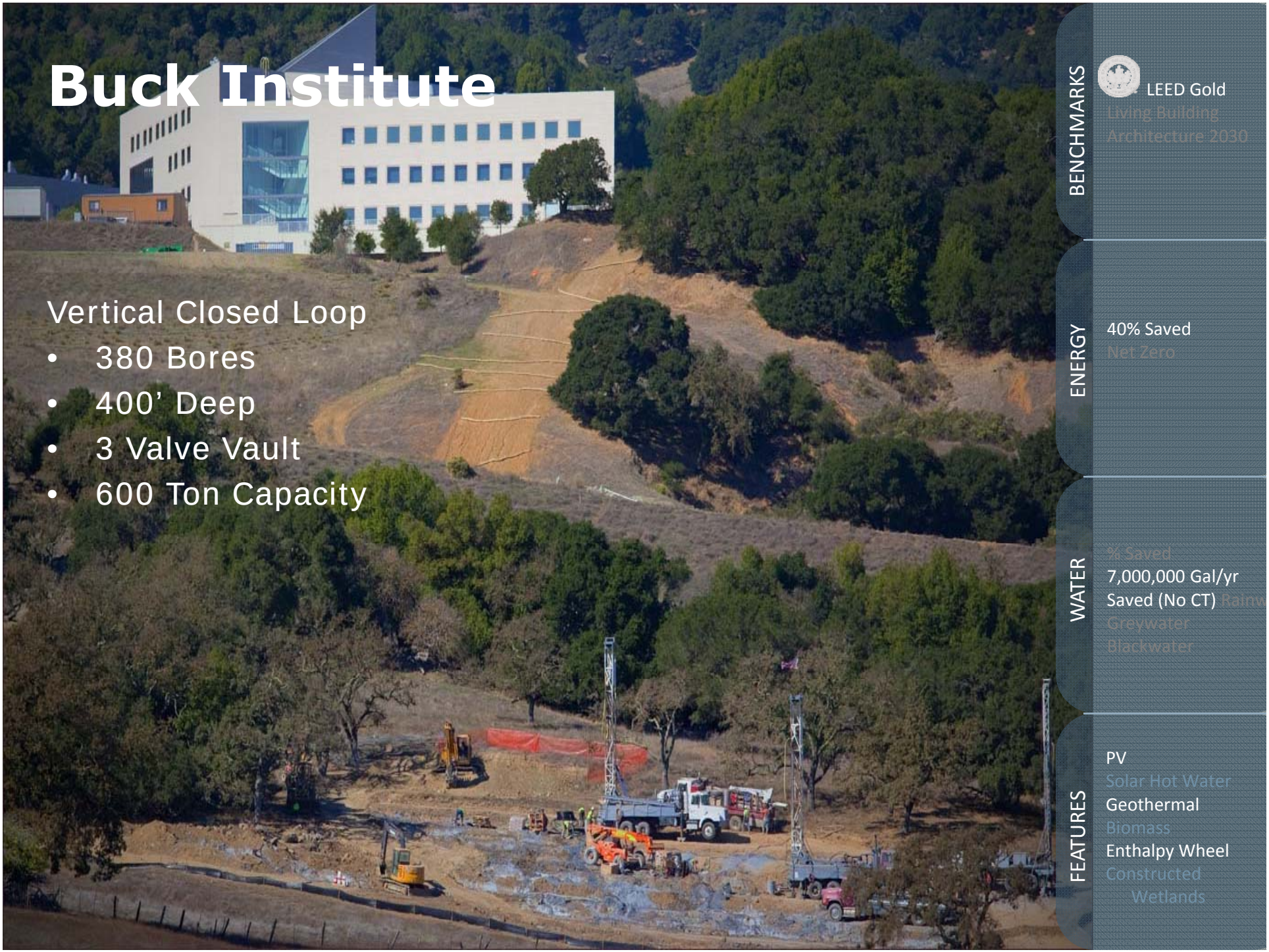
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed
Wetlands

Buck Institute



Vertical Closed Loop

- 380 Bores
- 400’ Deep
- 3 Valve Vault
- 600 Ton Capacity

BENCHMARKS

LEED Gold
Living Building
Architecture 2030

ENERGY

40% Saved
Net Zero

WATER

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7,000,000 Gal/yr Saved (No CT)
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Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed Wetlands

Geothermal Case Studies

Zoos & Visitor Centers

Oregon Zoo – Elephant Habitat

Oregon, CA

BENCHMARKS

LEED
Platinum
Living Building
Architecture 2030

ENERGY

88% Saved
EUI
Net Zero

WATER

% Saved
Rainwater
Greywater
Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Enthalpy Wheel
Constructed
Wetlands

USFWS Corn Creek Visitor Center

Mojave Desert, NV

Architect: Lucchesi Galati

BENCHMARKS

LEED
Platinum
Living Building
Architecture 2030

ENERGY

Net-Zero
EUI
Net Zero

WATER

% Saved
Rainwater
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Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Open Pond Loop
Biomass
Enthalpy Wheel
Constructed
Wetlands

Geothermal Case Studies

Art Museums

Bainbridge Art Museum

Bainbridge Island, WA

Architect: Asani LLC

RENEWABLES

LEED Silver

ENERGY

15% Saved
67 EUI
Net Zero

WATER

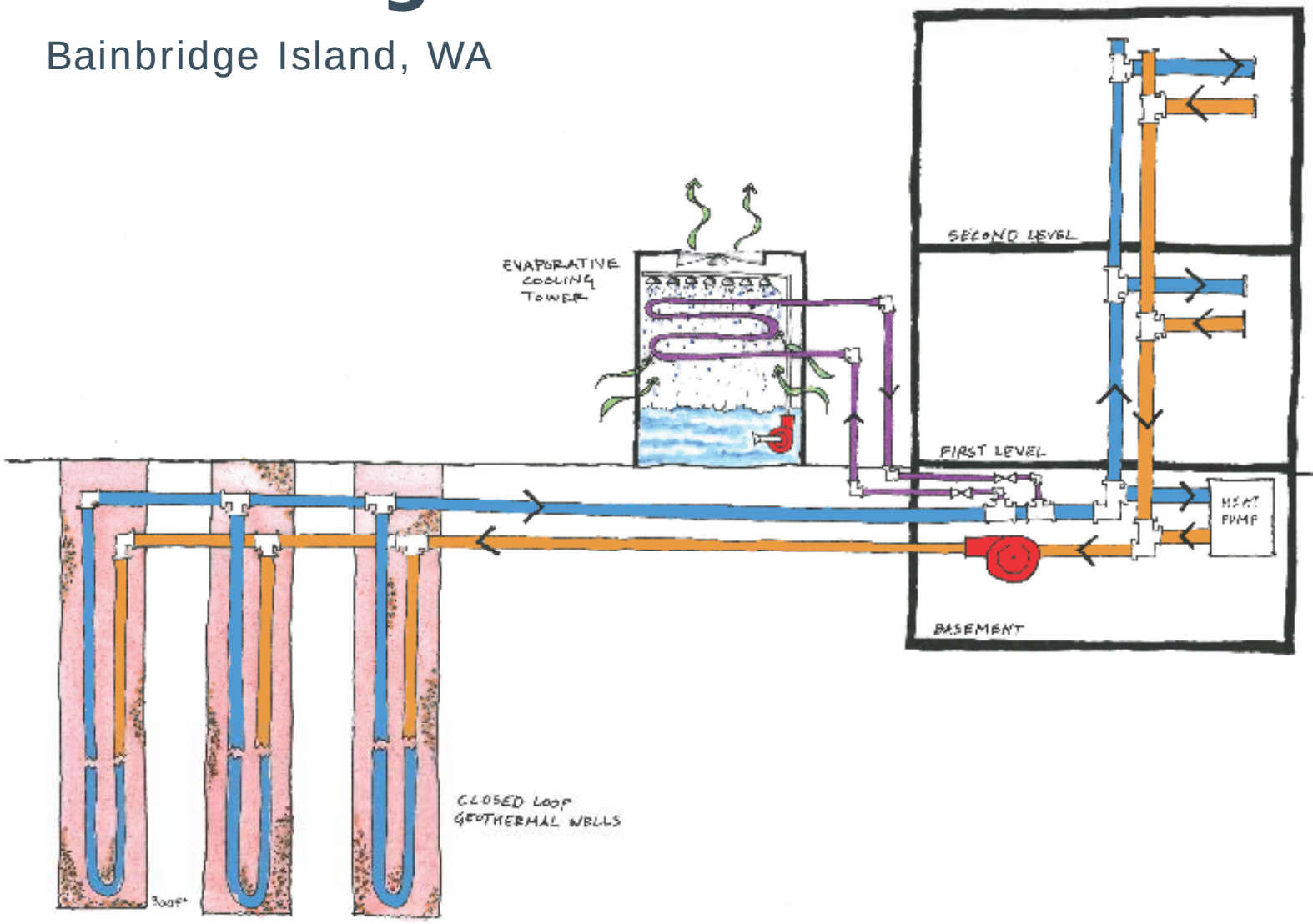
40% Saved
Rainwater
Greywater
Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Daylighting Controls
Constructed Wetlands

Bainbridge Art Museum

Bainbridge Island, WA



BENCHMARKS

LEED Silver

ENERGY

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Net Zero

WATER

40% Saved
Rainwater
Greywater
Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Biomass
Daylighting Controls
Constructed Wetlands

Nordic Heritage Museum

Seattle, WA

Architect: Mithun

BENCHMARKS

LEED Silver

ENERGY

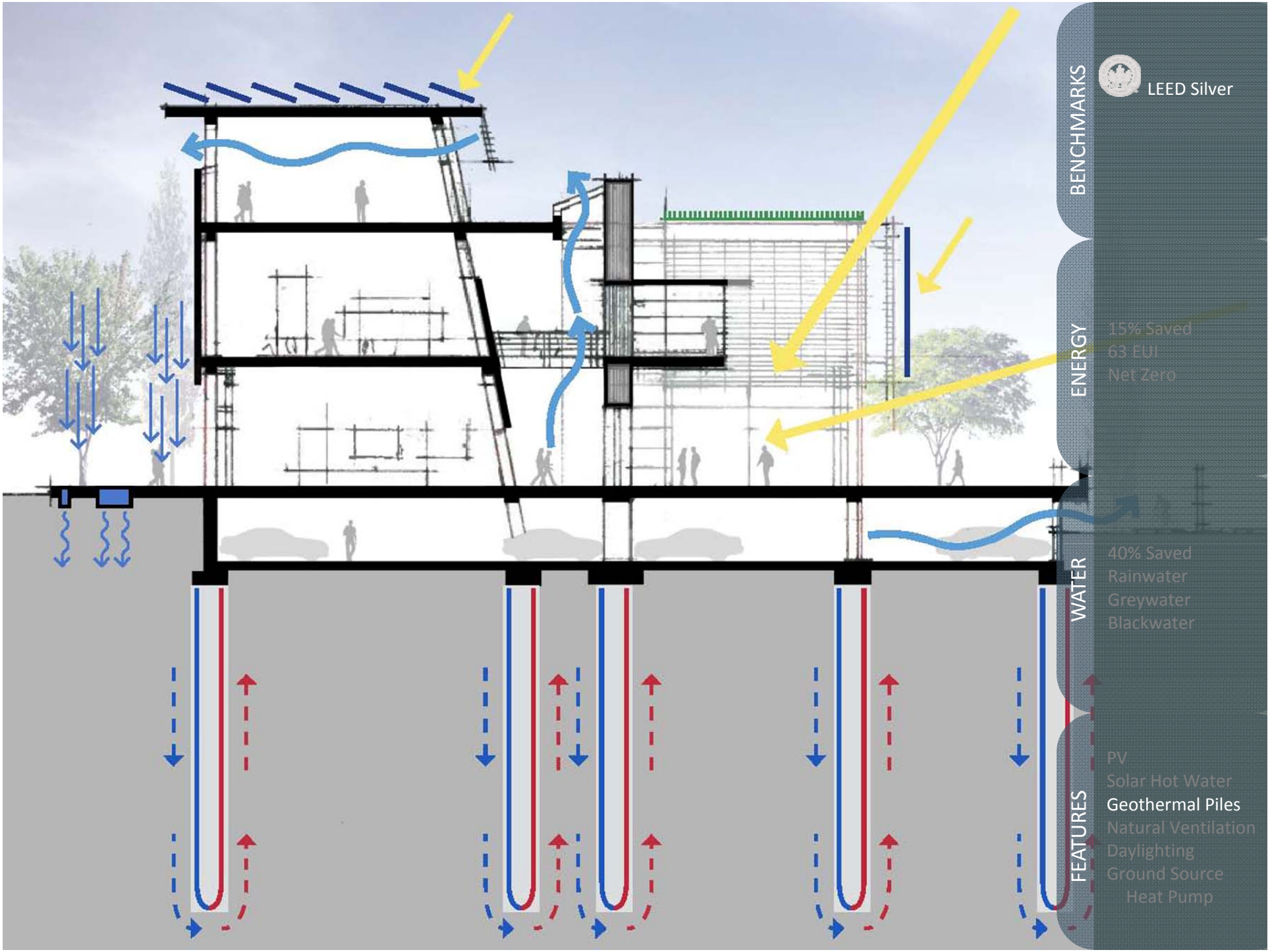
15% Saved
63 EUI
Net Zero

WATER

40% Saved
Rainwater
Greywater
Blackwater

FEATURES

PV
Solar Hot Water
Geothermal
Natural Ventilation
Daylighting
Ground Source
Heat Pump


BENCHMARKS
LEED Silver
ENERGY
15% Saved
63 EUI
Net Zero
WATER
40% Saved
Rainwater
Greywater
Blackwater
FEATURES
PV
Solar Hot Water
Geothermal Piles
Natural Ventilation
Daylighting
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Heat Pump

Geothermal Case Studies

Housing

Art Stable

Seattle, WA

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FEATURES

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"Geothermal Heat Pumps

Geothermal heat pumps are one of the **most efficient** ways to heat and cool your home. They can achieve **efficiencies two to three times greater** than commonly used air source heat pumps because they rely on **the relatively consistent ground temperatures** to transfer heat to or from a home. Across much of the United States, the temperature of the upper 10 feet of the ground remains **between 45°F and 75°F, and often between just 50°F and 60°F**. By contrast, air temperatures can range over the course of a year from below 0°F to over 100°F."

Source: EPA Website

U.S. DEPARTMENT OF ENERGY
Energy Efficiency & Renewable Energy

Questions ➲ Answers

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